ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY W. H. MAW AND B. ALFRED RAWORTH.

VOL. CVI.—FROM JULY TO DECEMBER, 1918.

London:

OFFICES FOR ADVERTISEMENTS AND PUBLICATION—35 & 36, BEDFORD STREET, STRAND, W.C.

1918.

UNIV. OF MICH.

ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND B. ALFRED RAWORTH.

OFFICES FOR ADVERTISEMENTS AND PUBLICATION, 35 & 36, BEDFORD STREET, STRAND, LONDON, W.C. 2

VOL. CVI.—No. 2740.] *LONDON: FRIDAY, JULY 5, 1918.* [Registered at the General Post Office as a Newspaper.] [PRICE...9d. BY IRELAND POST ... 11d.

Aveling & Porter, Ltd.,
ROCHESTER, KENT.
and 72, CANNON STREET, LONDON.
STEAM ROLLERS. ROAD LOCOMOTIVES.
STEAM CULTIVATING MACHINERY.
STEAM WAGONS. TRACTORS.
CEMENT-MAKING MACHINERY. 6308

A. G. Mumford, Ltd.,
CULVER STREET WORKS, COLCHESTER
ON ADMIRALTY AND WAR OFFICE LISTS.
ENGINES for Torpedo Boats, Yachts, Launches.
BOILER FEED PUMPS.
See Advertisement, page 33.
PATENT WATER-TUBE BOILERS.
AUTOMATIC FEED REGULATORS,
And Auxiliary Machinery as supplied to the Admiralty. 2179

Henry Butcher & Co.,
VALUERS AND AUCTIONEERS,
Specialising in the
ENGINEERING, FOUNDRY & METAL TRADES.
Also for
PLANT AND MACHINERY.
81 AND 84, CHANCERY LANE, LONDON, W.C. 2.
'Phone: Holborn 2295. 6391
Telegrams: Penetrancy, Holb., London.

Cranes.—Electric, Steam,
HYDRAULIC and HAND.
of all types and sizes.
GEORGE RUSSELL & CO., LTD., Motherwell, near Glasgow. 6451

STEEL TANKS, PIPES, GASHOLDERS, &c.
Thos. Piggott & Co., Limited,
BIRMINGHAM. 4457
See Advertisement last week, page 108.

Plenty and Son,
LIMITED.
MARINE ENGINEERS, &c.
NEWBURY, ENGLAND. 9039

Tank Locomotives.
Specification and Workmanship equal to Main Line Locomotives.
R. & W. HAWTHORN, LESLIE & CO., LTD., ENGINEERS, NEWCASTLE-ON-TYNE. 6450

The Glasgow Railway Engineering Company,
GOVAN, GLASGOW. LTD.
London Office—12, Victoria Street, S.W.
MANUFACTURERS OF
RAILWAY CARRIAGE, WAGON AND TRAMWAY WHEELS & AXLES.
CARRIAGE & WAGON IRONWORKS, also CAST-STEEL AXLE BOXES. 6289

P. & W. MacLellan, Limited,
CLUTHA WORKS, GLASGOW.
MANUFACTURERS OF
RAILWAY CARRIAGES AND WAGONS,
OF EVERY DESCRIPTION.
RAILWAY IRONWORK, BRIDGES, ROOFING, &c.
Chief Offices: 120, Trongate, GLASGOW. Od 8547
Registered Offices: 108½, Cannon St., London, E.C.

Fuller, Horsey, Sons & Cassell,
SPECIALISTS
in the
SALE AND VALUATION
of
PLANT AND MACHINERY 1834
and
ENGINEERING WORKS.
11, BILLITER SQUARE, E.C. 3.

Invincible Gauge Glasses.
BUTTERWORTH BROS, Ltd.,
Newton Heath Glass Works,
Manchester. Od 9758

Iron and Steel
Tubes and Fittings.
6143
The Scottish Tube Co., Ltd.,
HEAD OFFICE: 36, Robertson Street, Glasgow.
See Advertisement page 81.

Yarrow & Co., Ltd.,
SHIPBUILDERS AND ENGINEERS,
GLASGOW.
SPEEDS UP TO 45 MILES AN HOUR.
PADDLE OR SCREW STEAMERS OF EXCEPTIONAL SHALLOW DRAUGHT.
Repairs on Pacific Coast
by YARROWS, LIMITED, Victoria, British Columbia. 6093
SHIPBUILDERS, SHIP REPAIRERS AND ENGINEERS.

Campbells & Hunter, Ltd.
Gear Cutting.
Worm Wheels cut up to 15 ft. diam.
Bevel and Mitre Wheels planed up to 3 ft. diam.
DOLPHIN FOUNDRY, LEEDS. 4547

Yachts, Launches, or Barges,
Built complete with Steam, Oil or Petrol Motors, ; or Machinery supplied. Od 3951
VOSPER & CO., LTD., BROAD STREET, PORTSMOUTH

FOR
Sheet Metal Stampings or Pressings
write
GARTSHERRIE ENGINEERING & FORGE CO., 50, WELLINGTON STREET, GLASGOW. 6305

Oil Fuel Appliances.
SYSTEMS { PRESSURE, AIR, STEAM.
FOR BOILERS OF ALL TYPES.
Kermodes Limited,
35, THE TEMPLE, DALE STREET, LIVERPOOL; and
109, FENCHURCH STREET, LONDON. 4076
NAVAL OUTFITS A SPECIALTY.

Locomotives Tank Engines
designed and constructed by
MANNING, WARDLE AND COMPANY, LIMITED, Boyne Engine Works, Leeds. Od 2427
See their Illus. Advertisement, page 131, last week.

Cochran MULTITUBULAR AND CROSS-TUBE TYPES.
Boilers.
See page 97. 6455

RAILWAY AND TRAMWAY ROLLING STOCK.
Hurst, Nelson & Co., Ltd.
THE GLASGOW ROLLING STOCK AND PLANT WORKS, MOTHERWELL. Od 2393

"Gripoly"
MACHINE BELTING
FOR
Driving
—
Conveying
—
Elevating
—
SOLE MANUFACTURERS
Lewis & Tylor, Ltd.,
CARDIFF. 6385
LONDON. MANCHESTER. GLASGOW.

New Chicago Automatics,
Three Sizes, Delivery from Stock.
NEW CAPSTANS, 1¼ in. through the wire feed.
JOHN MACNAB, MARY STREET, HYDE.
Tel. No.: 78 Hyde. 6102

John Bellamy, Limited,
MILLWALL, LONDON, E. 1216
GENERAL CONSTRUCTIONAL ENGINEERS,
Boilers, Tanks & Mooring Buoys
STILLS, PETROL TANKS, AIR RECEIVERS, STEEL CHIMNEYS, RIVETED STEAM AND VENTILATING PIPES, HOPPERS, SPECIAL WORK, REPAIRS OF ALL KINDS.

Tubes and Fittings.
—
Stewarts and Lloyds, Ltd.,
Glasgow and Birmingham.
See Advertisement page 111. 6483

Rubber MANUFACTURERS
Packings "Redstone" "Bluestone"
GUTTA PERCHA & RUBBER, LIMITED.
Toronto - - Canada. 6702

CO^2 Plants (CARBON DI-OXIDE)
for Chemical & Mineral Water Mfrs. & Breweries.
READ & CAMPBELL, Ltd., 108, Victoria St., London, S.W. Telegrams—"Valerem, London."

CO^2 Fire Extincteurs
for Public and Private Bldgs., Electric Railways, &c.
THE BRITISH FIRE APPLIANCES Co., Ltd., 109, Victoria St., London, S.W. Telegrams—"Nonacid, London."

Inst. C.E., I. Mech. E., B.Sc.,
and all Engineering Examinations.—Mr. G. P. KNOWLES, B.Sc., Assoc. M. Inst. C.E., F.R.I., M.R.San.I., PREPARES CANDIDATES personally or by correspondence. Hundreds of successes. Courses may commence at any time.—39, Victoria St., Westminster, S.W. 6780

Chains (Electrically Welded or hand made) for all purposes; also Chain Fittings, Rings, Hooks, Swivels, Shackles, &c.; Pulley Blocks for use with Chains, Wire Rope or Hemp Rope; Repetition Smithwork and Castings, plain or machined. Reliable quality; prompt deliveries and reasonable prices.—STRINGHAS (Cradley Heath), Limited, Cradley Heath, Staffs. 6730

THE GLASGOW ROLLING STOCK AND PLANT WORKS
Hurst, Nelson & Co., Ltd.,
Builders of RAILWAY CARRIAGES, WAGONS ELECTRIC CARS and EVERY OTHER DESCRIPTION OF RAILWAY AND TRAMWAY ROLLING STOCK.
Makers of WHEELS and AXLES, RAILWAY PLANT.
FORGINGS, SMITH WORK, IRON AND BRASS CASTINGS.
PRESSED STEEL WORK OF ALL KINDS.
Registered Office and Chief Works: Motherwell.
London Office: 14, Leadenhall Street, E.C.
See Illustrated Advt. in alternate issues. Od 2393

Builders of Locomotives,
HEAVY and LIGHT.
All Gauges and Types.
Address: Export Department,
H. K. PORTER CO.,
11, Battery Place, New York.
Or R. G. COTTRELL,
5, London Wall Bldgs., London, England.
Cable Address—STAPELY, NEW YORK. 6660
New Catalogue 13 A mailed on application.

R. Y. Pickering & Co., Ltd.,
(ESTABLISHED 1864.)
BUILDERS of RAILWAY CARRIAGES & WAGONS.
MAKERS of WHEELS and AXLES of all kinds.
RAILWAY WAGONS FOR HIRE.
Chief Works and Offices:
WISHAW, near GLASGOW.
London Office:
3, VICTORIA STREET, WESTMINSTER, S.W. 6393

Machine and Engineering
WORK of all description undertaken for Manufacturers, Patentees, &c. Also repairs and renewals. Best work, moderate charges.—ROGERS & RUSSELL, LTD., Queen's Wharf, Hammersmith.
NEW PATENT ACT.—ROGERS & RUSSELL, Ltd., are prepared to undertake the manufacture of articles at present made abroad, and will be pleased to hear from firms desiring such work executed. 9211

Royles Limited,
ENGINEERS, IRLAM, MANCHESTER.
FEED WATER HEATERS,
CALORIFIERS, EVAPORATORS,
CONDENSERS, AIR HEATERS,
STEAM AND GAS KETTLES.
Rowe's Patents.
Merrill's Patent TWIN STRAINERS for Pump Suctions.
SYPHONIA STEAM TRAPS, REDUCING VALVES.
High-class GUNMETAL STEAM FITTINGS.
WATER SOFTENING and FILTERING. 5720

Yarrow Patent Water-tube Boilers.
6084
MESSRS. YARROW & CO., UNDERTAKE the PRESSING and MACHINING of the various parts of Yarrow Boilers, such as the Steam Drums, Water Pockets, and Superheaters for British and Foreign Firms not having the necessary facilities.
YARROW & CO., LTD., SCOTSTOUN, GLASGOW.

Matthew Paul & Co., Ltd.
LEVENFORD WORKS, **Dumbarton.** 6054
See Full Page Advt., page 73, June 28.

Forgings.
Walter Somers & Co., Ltd.,
HALESOWEN. 6340

"Delta" Brand HIGH-CLASS ENGINEERING ALLOYS.
Forgings, Castings, Bars, Sheets, Wire, Tubes.
THE DELTA METAL CO., LTD., 6363
E. GREENWICH, LONDON, S.E. 10 (& at Birmingham.

Taylor & Challen Presses.
9198
TAYLOR & CHALLEN, LTD., Engineers, BIRMINGHAM
See Full Page Advertisement June 28.

Railway Switches and Crossings.
T. SUMMERSON & SONS, LIMITED, DARLINGTON. 6300

A Time Recorder, as New,
guaranteed, latest model. WHAT OFFERS? —A. C. PHILLEY, 140, Farringdon Road, E.C.1. G156

Cement.—Maxted & Knott,
LTD., Consulting Cement Engineers, ADVISE GENERALLY on proposed Cement Schemes FOR ENGLAND AND ABROAD. ADVICE ONLY. Highest references. Established 1900.
Address, BURNETT AVENUE, HULL.
Cablegrams: "Energy, Hull." 6290

Improved High Pressure
RENEWABLE DISC GLOBE VALVE.
See our Advertisement in last week's issue, page 135.
BRITISH STEAM SPECIALITIES, LTD., Bedford Street, Leicester. 2290

Gas and Oil Engine Repairs.
—E. J. DAVIS & CO., Great Eastern Road, Stratford, E. 15.
Tel.: 128 and 797 Stratford.
Gram.: Rapidising, London. 1716

CHANTIERS & ATELIERS
Augustin - Normand
67, rue de Ponthieu—LE HAVRE (France). 2190
Destroyers, Torpedo Boats, Yachts and Fast Boats. Submarine and Submersible Boats.
NORMAND'S Patent Water-tube Boilers, Coal or Oil Heating. Diesel Oil Engines.

Centrifugals.
Pott, Cassels & Williamson,
MOTHERWELL, SCOTLAND. 6348
See half-page Advertisement page 66, June 14.

The Manchester Steam Users' ASSOCIATION.

For the Prevention of Steam Boiler Explosions and for the Attainment of Economy in the Application of Steam. 9, MOUNT STREET, MANCHESTER.

Chief Engineer: C. E. STROMEYER, M.I.C.E.

Founded 1854 by Sir WILLIAM FAIRBAIRN.

Certificates of Safety issued under the Factory and Workshops Act, 1901. Compensation for Damages and Liabilities paid in case of Explosions. Engines and Boilers inspected during construction. 6681

MILLAR'S SYSTEM OF SHIP'S FRAMING.

In the Law Officer's Department, Royal Courts of Justice, the Solicitor-General has heard an Appeal by J. W. Isherwood, of London, against the decision of the Comptroller-General of Patents, in the matter of an application for Patent by William Millar, of Greenock, for the Millar System of Ship's Framing. The Comptroller-General had decided to grant the Patent to William Millar, and the Appeal of J. W. Isherwood has been dismissed by the Solicitor-General.

(Counsel for William Millar, Mr. Thomas Terrell, K.C., instructed by Johnsons, Glasgow. Counsel for J. W. Isherwood, Mr. Hunter Gray, instructed by W. Crossley). L 937

THE

University of Liverpool.

SESSION 1917-18.

SUMMER TERM COMMENCES 23RD APRIL.

FACULTY OF ENGINEERING.

DEAN—J. WEMYSS ANDERSON, M.Eng., M.Inst.C.E.

PROFESSORS AND LECTURERS.

ENGINEERING.

Harrison Professor — W. H. WATKINSON, M. Eng., M. Inst. C.E., M.I. Mech. E., M.I. HB.

Lecturer in Strength of Materials—W. MASON, D.Sc., Assoc. M.Inst. C.E.

ELECTRICAL ENGINEERING.

David Jardine Professor, D. W. MARCHANT, D.Sc., M.I.E.E.

Lecturer in Municipal Electrical Engineering—Associate Professor A. BROMLEY HOLMES, M.Eng., M. Inst. C.E., M.I.E.E.

CIVIL ENGINEERING.

Professor S. W. PERROTT, M.A.I., M.Inst.C.E.

Lecturer in Railway Engineering—Associate Professor Sir J. A. F. ASPINALL, M.Eng., M. Inst. C.E., M.I. Mech. E.

Lecturer in Municipal Engineering—Associate Professor J. A. BRODIE, M.Eng., M.Inst.C.E., M.I. Mech. E.

Lecturer in Dock and Harbour Engineering—Associate Professor A. G. LYSTER, M. Eng., P. Inst. C.E.

Lecturer in Engineering Geology—J. VINCENT ELSDEN, D.Sc., F.G.S.

Lecturer in Dock and Harbour Construction—T. R. WILTON, M.A., Assoc. M.Inst. C.E.

NAVAL ARCHITECTURE.—Alexander Elder Professor—Professor T. R. ABELL, M. Eng., R.C.N.C., Ret., M. Inst. N.A.

MARINE ENGINEERING.—Professors and Lecturers in Naval Architecture and Engineering.

DESIGN AND DRAWING AND REFRIGERATION.—Associate Professor J. WEMYSS ANDERSON, M. Eng., M. Inst. C.E., M.I. Mech. E.

MATHEMATICS.—Professor F. S. CAREY, M.A.

PHYSICS.—Lyon Jones Professor—L. R. WILBERFORCE, M.A.

CHEMISTRY.—Grant Professor—E. C. C. BALY, M.Sc., F.R.S., F.I.C.

The Special Matriculation Examination, or the Entrance Examination, must be passed to secure admission to Courses of Instruction in the Faculty.

The Prospectus of the Faculty may be obtained on application to the undersigned. K 132

EDWARD CAREY, Registrar.

The University of Sheffield.

SESSION 1918-19.

VICE-CHANCELLOR—W. RIPPER, C.H., D.Eng., D.Sc., M.Inst.C.E., J.P.

DEPARTMENT OF APPLIED SCIENCE, COMPRISING FACULTIES OF ENGINEERING AND METALLURGY.

PROFESSORS IN THE DEPARTMENT:—

Mechanical Engineering—W. RIPPER, C.H., D.Eng., D.Sc., M.Inst.C.E., J.P.

Metallurgy—J. O. ARNOLD, F.R.S.

Mining—F. H. ARMSTRONG, M.Sc., A.M.Inst.C.E.

Applied Chemistry—L. T. O'SHEA, M.Sc.

Mathematics—A. H. LEAHY, M.A.

Physics—S. R. MILNER, D.Sc.

Chemistry—W. P. WYNNE, D.Sc., F.R.S.

Geology—W. G. FEARNSIDES, M.A.

Electrical Engineering—E. H. CRAPPER, B.Eng., M.I.E.E. (Lecturer).

Civil Engineering—J. HUSBAND, B.Eng., A.M.Inst. C.E. (Lecturer).

Glass Technology—W. E. S. TURNER, D.Sc. (Lecturer).

The subjects in which courses of study are provided include Engineering, Metallurgy, Coal Mining, Applied Chemistry, Mathematics, Physics, Chemistry, Geology, Glass Technology and Refractories.

The DEPARTMENT OF ENGINEERING includes courses in Civil, Mechanical, Electrical and Chemical Engineering, and students specialise in one or other of these branches in the third year of their course. The Course in Engineering extends over three years and prepares for the degree of Bachelor of Engineering (B.Eng.) or for the Associateship of the University in Engineering. Special three years' courses are arranged for Works' pupils, who come to the University from the works in Sheffield, or from other centres, taking six months' study at the University and six months' practice at the works each year.

The DEPARTMENT OF METALLURGY includes (a) the Metallurgy of Iron and Steel, and (b) the Metallurgy of the Non-ferrous Metals. The course in Metallurgy extends over three years, and prepares for the degree of Bachelor of Metallurgy (B.Met.), or for the Associateship of the University in Metallurgy. The equipment of this department is on an exceptionally complete and practical scale.

The work of the DEPARTMENT OF COAL MINING includes a three or four years' Diploma course, consisting of six months at the University and six months at a colliery.

The DEPARTMENT OF APPLIED CHEMISTRY deals specially with the subjects relating to various branches of Coal Mining, and of the Coal and Coke Industries.

The DEPARTMENT OF GLASS TECHNOLOGY provides (a) a Diploma Course, requiring systematic study of the science and practice of Glass Manufacture, for a period of three years, and (b) Part time and special courses.

The DEPARTMENT OF REFRACTORIES provides special courses of instruction and opportunities for research in problems connected with the application of refractory materials to industrial purposes.

The LECTURE COURSES of all the Departments are supplemented by Practical training in Laboratories, Workshops and Foundries fully equipped for the purpose of advanced scientific teaching, investigation and research.

Part time Courses are arranged for Students who desire to take special portions of any of the regular courses.

The LECTURE COURSES commence 2nd October, 1918.

The TECHNICAL LABORATORY COURSES commence 23rd September, 1918. L 940

W. M. GIBBONS, Registrar.

MANCHESTER MUNICIPAL

College of Technology (UNIVERSITY OF MANCHESTER).

Principal: J. C. M. GARNETT, M.A. (late Fellow Trin. Coll. Cam.).

Vice-Principal: R. M. WRONG, M. A. (Fellow Magdalen Coll, Oxford).

The Session 1918-1919 will open on 3rd October. Matriculation and Entrance Examinations will be held in July and September. Matriculated students may enrol for 1918-19 from 1st August, 1918, and if under 18 years of age are eligible for membership of the Officers' Training Corps.

DEGREE COURSES IN TECHNOLOGY.

The Prospectus gives particulars of the courses leading to the Manchester University degrees (B.Sc. Tech. and M.Sc.Tech.) in the Faculty of Technology, in the following Departments:—

MECHANICAL ENGINEERING (Prof. G. G. Stoney, F.R.S.).

ELECTRICAL ENGINEERING (Prof. Miles Walker, M.A.).

SANITARY ENGINEERING (including Municipal Engineering).

THE CHEMICAL INDUSTRIES (including General Chemical Technology, Bleaching, Dyeing and Dyestuff Manufacture, Printing, Papermaking, Fermentation Industries, Metallurgy, Fuels).

TEXTILE INDUSTRIES, MINING, ARCHITECTURE.

PRINTING AND PHOTOGRAPHIC TECHNOLOGY.

ADVANCED STUDY AND RESEARCH.

The College possesses extensive laboratories and workshops, equipped with full-sized modern apparatus, including machines specially constructed for demonstration and original research.

PROSPECTUSES of University Courses or of Part-time Courses sent free on application. M 6

TENDERS.

BOROUGH OF SANDWICH.

TO ENGINEERS AND OTHERS.

The Corporation of Sandwich invite

Tenders for the Purchase of their STEAM PUMPING PLANT at their Waterworks, Woodnesborough, Sandwich, consisting of Well Pumps, Engines and Boilers complete. Particulars of the plant and Conditions of Sale may be obtained from the Borough Surveyor, Sandwich, to whom Tenders should be delivered on or before July 20th. The above plant can be seen at work by intending purchasers at any time during the day upon application being made to the Borough Surveyor.

The Corporation reserve to themselves the right to accept Tenders for the whole or part of the above machinery, and do not bind themselves to accept the highest or any Tender.

R. SAUNDERS,
Borough Surveyor.

Borough Surveyor's Office,
Sandwich, 3rd July, 1918. L 983

APPOINTMENTS OPEN.

PORTSMOUTH WATERWORKS COMPANY.

The above-named Company requires the

Services as early as possible of a RESIDENT WORKS SUPERINTENDENT to take permanent charge (under the Engineer and General Manager) of a large portion of their Works and District, comprising Pumping Machinery ("Worthington" and "Beams.") Filter Beds, Reservoirs, Springs, Incidental Works and Properties.

The Applicant appointed must be well qualified to carry out the duties of the appointment, skilled and tactful in the management of men, of whom he will usually have about fifty under his charge.

Salary £300 per annum, with good house and garden, free of rent and rates.

Applications, stating age and experience, accompanied by testimonials or references (enclosed in envelope marked "SUPERINTENDENT," and stating the earliest date at which the candidate can take up his duties, to be addressed to The Chairman, Portsmouth Waterworks Company, and delivered not later than mid-day on Wednesday, the 24th inst.

HERBERT ASHLEY,
M. Inst., C.E., M.I. Mech. E.
Engineer & General Manager.

Commercial Road, Portsmouth.
July 3rd, 1918. M 2

Wanted, for Large Shipbuilding and Engineering Establishment, an ACCOUNTANT to take charge of financial books under slight supervision. Applicant must have had similar experience. No one already employed on Government work will be engaged.—Apply, stating age, experience and salary required, to your nearest EMPLOYMENT EXCHANGE, mentioning this Journal and L 972.

Gentleman with Qualified Engineering or Mechanical Experience OFFERED UNIQUE OPENING where investment of £2 000—£3,000 capital and services are required. Genuine. Principals only need apply.—Address, L 963, Office of ENGINEERING.

Wanted, for September, TEACHER of Engineering Drawing and Geometry; full-time. Must be exempt, ineligible, or discharged from military service.—Apply, for further particulars, PRINCIPAL, Woolwich Polytechnic, S.E. 18. L 941

Wanted, Correspondence CLERK, ineligible, with experience in machine and small tools, taps, grinding wheels, &c. Must be used to dictating and capable of taking charge of correspondence and experienced in similar work. State fully previous positions and wages required; Glasgow district.—Address, L 939, Offices of ENGINEERING.

Works Manager Wanted by one of the largest manufacturers of heavy motor vehicles in the country. Experience in the latest methods of production is essential. No one on Government work will be engaged.—Address, giving fullest particulars of experience, with dates, age and salary expected, L 881, Offices of ENGINEERING.

Assistant Works Manager WANTED for Marine Engineering Company on East Coast. Must be 6 o'clock man and capable of organising work (both new and repair) on up-to-date methods. No one on Government work need apply.—Apply your nearest EMPLOYMENT EXCHANGE, stating age, experience, and salary required, and mentioning No. A 5559. L 878

Wanted, for South-East France, Contractors' Agents, Builders' Assistants, Builders' Clerks, Timekeepers, Accountants and Book-keepers. First-rate salaries paid to the right men. Knowledge of French advantageous.—Apply in writing with fullest particulars and references, stating wages required to SOMERVILLES, 120, Victoria Street, S.W.1. M 11

Analytical Chemists.—Assistants REQUIRED, over 23 or ineligible for Army. Experienced analysts. Steel works experience preferred but not essential. No person already employed on Government work will be engaged.—Apply your nearest EMPLOYMENT EXCHANGE, quoting reference No. A 5611. L 948

Required, for a Large Shipbuilding and Engineering Establishment, a first-class MAN to act as Assistant to Commercial Manager. Applicant must have had Accountancy and General Commercial training and experience and be cognisant with Shipyard practice.—Apply, stating age, experience and salary required, to your nearest EMPLOYMENT EXCHANGE, mentioning this Journal and L 971.

Rate Fixer.—First-class Tool-room Rate Fixer REQUIRED, by a firm in the Midlands engaged on Aero Engine production. Applicants must have had a tool room experience of high-class work. No person already engaged on Government work will be engaged.—Apply to your nearest EMPLOYMENT EXCHANGE, mentioning No. A 5503. L 803

Ratefixers.—Wanted at Once, several experienced Ratefixers for large firm in the Eastern Counties manufacturing Internal Combustion Engines, both Aero and Marine types. Accustomed to fixing piecework rates on approved modern methods for machining and fitting. State age, experience and salary required. No one on Government work need apply.—Apply, your nearest EMPLOYMENT EXCHANGE, mentioning this Journal and L 981.

Rate-Fixer Required for Repetition Work (small engineering parts). No man already engaged on Government work or residing more than 10 miles away need apply.—Write, stating age, experience, and wages required, to MANAGER, Sterling Works, Dagenham, Essex. L 949

Rising Firm of Engineers and Contractors for Reinforced Concrete Constructions with large interests in Concrete Shipbuilding OFFER POST as CHIEF ENGINEER for their Westminster Drawing Office to competent expert Engineer with several years practical experience. No one at present on Government work or resident more than 10 miles away will be engaged.—Address, stating age, experience, and salary required to L 990, Offices of ENGINEERING.

Foreman Engineer Wanted, accustomed to the Charge of Heavy Machine Tools. Fitting and Erecting of Rolling Mill Machinery. No person already on Government work will be engaged.—Apply, stating age, wages and experience, to your nearest EMPLOYMENT EXCHANGE, mentioning No. A 5617. L 953

Required, Assistant to Purchasing and Sales Manager of Engineering Firm. Technical training necessary. Ineligible. No one already on Government work or resident more than 10 miles away will be engaged. State full experience, salary required, etc.—Address, L 969, Offices of ENGINEERING.

Wanted, Staff Assistant for Electrical office work in a Government department at Portsmouth. Applicants to have technical training and experience in the design of electrical apparatus. Salary £280 per year.—Address, BOX 88, WILLINGS, 125, Strand, London, W.C. 2. L 973

Draughtsmen Wanted for Designing Lathes. No one already employed on Government work will be engaged. State age, experience, and salary required.—Apply through your nearest EMPLOYMENT EXCHANGE, mentioning this Journal and L 939.

Experienced Aero Engine DRAUGHTSMEN, of designing ability, REQUIRED by a North Midland Aero Factory. Good position and salaries to suitable applicants. No person already on Government work will be engaged.—Apply your nearest EMPLOYMENT EXCHANGE, mentioning No. A 5465. L 730

Draughtsman Required to TAKE CHARGE of Coal Washery Department. Experienced men only need apply.—Full particulars in the first place to K 624, Offices of ENGINEERING.

Experienced Mechanical DRAUGHTSMAN REQUIRED for London district. Knowledge of small steam Turbines or Pumps would be a recommendation. Position permanent and progressive to suitable man. No one at present engaged on Government work need apply.—State full particulars, age and salary required to your nearest EMPLOYMENT EXCHANGE, mentioning this Journal and L 970.

Required at Once, Draughtsmen, accustomed to Aero Engine work, also LADY TRACERS. Only tracers who are capable of very neat work need apply. No one engaged on Government work or residing more than ten miles away will be engaged.—Address, L 938, Offices of ENGINEERING.

Draughtsman Required, with good experience in design of Steelworks Machinery preferred, although applications from high-class men with other experience would be considered. No one already on Government work will be engaged.—State age, experience and salary required and when at liberty, to your nearest EMPLOYMENT EXCHANGE, quoting No. A 4694. K 303

Draughtsman Required Immediately, thoroughly experienced in Semi-Diesel Oil Engines, land and marine. Good salary will be paid to suitable man. No person already on Government work will be engaged.—Apply, stating age, experience, and salary required, to your nearest EMPLOYMENT EXCHANGE, quoting No. A 5309. L 806

Draughtsman.—Wanted, immediately, a first-class Engineer-Draughtsman, thoroughly acquainted with general Marine Engineering work. No one already on Government work will be engaged.—Apply, stating age, experience and salary required, to your nearest EMPLOYMENT EXCHANGE, mentioning this Journal and L 860.

Draughtsmen Required for temporary service in an Admiralty Department, a knowledge of Marine Engineering being essential. Salary up to £6 a week, inclusive of war bonus with overtime in addition, according to qualifications.—Applicants to state age and details of experience, to reach BOX No. 1675, WILLINGS, 125, Strand, London, W.C. 2, not later than July 31st. L 877

Wanted, Experienced and capable Jig and Tool DRAUGHTSMAN, preferably with experience of Motor Vehicle Manufacture. London district. No person already on Government work will be engaged.—Apply, stating age, salary and full particulars of experience, to your nearest EMPLOYMENT EXCHANGE, mentioning No. A 3929. L 802

Draughtsmen Required in Important munition works. Those accustomed to furnace design preferred. No one on Government work or living more than 10 miles away will be engaged. State experience, age and salary required.—Apply to BOX 134, Advertising Offices, 84, Queen Victoria Street, London, E.C. 4. L 934

Tracers Required in Important munition works. Must have had previous experience. No one on Government work or living more than 10 miles away will be engaged. State age and salary required.—Apply to BOX No. 136, Advertising Offices, 84, Queen Victoria Street, London, E.C. 4. L 935

Draughtsman Required, accustomed to the Design of Centrifugal Pumps, and preferably with knowledge of Electrical Machinery. Good progressive situation for the right man. No one engaged on Government work or residing more than 10 miles away need apply.—State age, training, and experience and salary required, to your nearest EMPLOYMENT EXCHANGE, mentioning this Journal and L 443.

Wanted Immediately, for Midland firm engaged on Aero Engine work, Jig and Tool DRAUGHTSMAN as Checker. Good salary and prospect for suitable man. No person already on Government work will be engaged.—Apply to your nearest EMPLOYMENT EXCHANGE, mentioning No. A 5426. L 668

Draughtsmen.—A Controlled Establishment in the West Riding of Yorkshire, engaged on important high priority work, REQUIRE the SERVICES of a competent MAN, with first-class experience in General Engineering work; also experienced MAN for medium size machine tool work. No person already on Government work will be engaged.—Apply, stating full particulars, to your nearest EMPLOYMENT EXCHANGE, mentioning A 4965. L 646

A Lady Tracer is also REQUIRED. The above positions are permanent to reliable individuals. No person already on Government work will be engaged.—Apply, stating full particulars, to your nearest EMPLOYMENT EXCHANGE, mentioning A 4965. L 646

Two Experienced Mechanical DRAUGHTSMEN, good permanent prospects, preference to applicants with knowledge internal combustion engines.—Apply, stating age, salary required, and particulars to your nearest EMPLOYMENT EXCHANGE, mentioning this Journal and L 998. No person already employed on Government work will be engaged.

Crane Draughtsmen.—Leading and Junior Draughtsmen REQUIRED for London district, having either good experience in Steelwork Machinery, Shipbuilding Berth Equipment or General Crane work, although applications from high-class men with other experience would be considered. Permanency for reliable, capable men.

No person employed on Government work will be engaged.—State fully experience, training, age and salary, to your nearest EMPLOYMENT EXCHANGE, mentioning this paper and L 771.

ENGINEERING.

A NEW THEORY OF THE STEAM TURBINE.

By HAROLD MEDWAY MARTIN, Wh.Sc., A.C.G.I.

THE rapid development of the steam turbine during the past few years has been largely attributable to the circumstances that from the standpoint of thermodynamics the steam turbine is a much simpler form of prime mover than the reciprocator. The internal surface of a steam engine cylinder is at one time hot and at another time cold. The interchange of heat between the walls of the working fluid is reversed during every cycle. There are also commonly considerable losses by valve leakage, which are difficult to estimate, and may change from day to day. The necessity for clearance gives rise to other losses, and the wastage of energy in all these varied directions, is generally large, and always uncertain, varying widely from engine to engine. Success in the building of economical reciprocators has been, in fact, largely a matter of cut and try, helped but little by theoretical considerations save of the most general character. With the steam turbine, on the other hand, it was soon found that theoretical considerations were much more directly applicable, and that by the use of a few coefficients provided by experience a pretty reliable estimate could be made as to the probable performance of most types of turbine of which the drawings were available. Nevertheless, experience disclosed some remarkable anomalies, some of which have not until now been elucidated. One of the most disconcerting was the well established experimental result, that under certain conditions the weight of steam discharged from a nozzle was actually greater than what was physically possible according to the then accepted theory.

By those, who did not assume it to be merely an experimental error, this anomaly was commonly attributed to moisture in the steam, an explanation which appeared the more plausible, in that no such perplexing violation of apparently well-established natural laws, was recorded when nozzle experiments were made with superheated steam. When, however, the trouble was taken to work out the degree of wetness which would be required to account for the results recorded, it was realised immediately that the explanation must be sought in some other direction. In fact, to bring this theory into accord with experiment would involve the presence of anything between 10 per cent. and 20 per cent. of moisture in the supply of steam at the disposal of the experimenters.

In a paper presented to the Institution of Mechanical Engineers, in 1912, Professor J. B. Henderson reviewed the observations made in a number of apparently reliable nozzle tests, and drew attention anew to this curious and disturbing discrepancy between theory and experiment. This paper re-directed attention to the matter. Many suggestions were proferred in explanation of the anomaly, but only one has proved tenable when exhaustively examined. On this hypothesis, first advanced in ENGINEERING, the anomaly is attributed to a fundamental error in the then accepted theory of the efflux of steam. That theory assumed that the expansion of wet steam normally proceeds under conditions of thermal equilibrium, although Aitken had definitely proved, as far back as 1880, the falsity of this hypothesis.* Moreover, Callendar and Nicolson, in their paper read before the Institution of Civil Engineers in 1897, had recorded observations which went to show that steam as it expanded behind the piston of a steam engine, was very distinctly supersaturated.

Although the experiments of Aitken and the later ones of C. T. R. Wilson should have been conclusive as to the error involved in the ordinary theory of the efflux of wet steam, it required the highly ingenious experiments of Dr. Stodola to convince engineers in general that the older hypothesis must be abandoned. Callendar in his paper on the "Steady Flow of Steam through a Nozzle or Throttle," published by the Institution of Mechanical Engineers in 1915, has given an exhaustive study of the whole problem.

It is proposed in what follows to give what appear to be very strong reasons for believing that another great outstanding anomaly in steam-turbine engineering is to be traced to the same error. Actual experience with steam turbines affords, in short, much weighty evidence in favour of the view that so far from the steam being in thermal equilibrium in the "saturated field" of the Mollier diagram, it never is in thermal equilibrium until the condenser is attained. The relation between volume and pressure during the expansion of wet steam is accordingly never the same as if thermal equilibrium were established. Of course, every station engineer knows that if he opens up his turbine he will find a distinct difference in the appearance of the blading which has been exposed only to superheated steam and that which on the ordinary theory has been subjected to the action of wet steam. The region in which the steam has lost its superheat is, in fact, very definitely marked, but this merely proves that a film of moisture is deposited on any surface exposed to supersaturated steam, as theory indicates must be the case. Indeed, it is this very phenomenon which for so many years prevented the detection of under-cooling in steam turbines and steam engines. In any attempt to take the temperature of the steam by means of a thermometer, a film of moisture was immediately deposited on the bulb or on the exterior of the thermometer pocket, if the steam were supersaturated. The thermometer recorded accordingly the temperature of this film, and not that of the surrounding vapour. Nevertheless, engineers have noted for many years past, that the temperature of the steam as indicated by a thermometer placed in a turbine exhaust pipe was sensibly below that corresponding to its pressure.* An example is afforded by the following observations for which the writer is indebted to Mr. W. Chilton, of the Brush Electrical Engineering Co., Limited, Loughborough.

Exhaust pressure inches of Hg... ...	0.671
Corresponding temperature deg. F. ...	67.2
Observed temperature	61.0

Many similar observations have been recorded. This particular instance is, however, notable for the very high vacuum and correspondingly low steam temperature, which makes it impossible to admit that the defect of temperature is due to losses of heat by conduction. This is the usual explanation proffered for these low readings. When, however, it is remembered that the smoke-box door of a locomotive is cool enough to touch with the hand when the engine is running at 50 miles an hour, it is incredible that surfaces washed by wet steam moving at say 300 to 400 miles per hour could differ sensibly in temperature from the steam were the steam itself in a condition of thermal equilibrium.

The low readings actually observed are the more remarkable in that experiments have shown that a thermoscope immersed in a current of a permanent gas tends to give too high a reading† owing to the adiabatic compression of the fluid against the obstacle. In the case of turbine exhaust temperatures it has been found that the greater the care taken to shield the thermometer pocket from the full rush of the passing steam the closer is the thermometer reading to the equilibrium value. This is what would naturally be anticipated. The temperature of the film deposited on the thermometer pocket depends upon the rate of interchange of its surface molecules with the under-cooled vapour. If more molecules condense than evaporate the film will thicken and rise in temperature owing to the liberation of latent heat. In a quiet space the film on the thermometer will soon surround itself with a jacket of molecules not differing much

* That this would be the case was suggested in Maxwell's Heat. Edition of 1880, page 290.

* It would be interesting to try if more reliable thermometer readings could not be obtained by coating the exterior of the pocket with some anti-hygroscopic substance. In view of the high vacua and consequent low temperatures now obtained, an experiment of this kind would appear to be feasible.

† "The Evolution of the Parsons' Steam Turbine" by Alex. Richardson, A.I.N.A., page 17.

in temperature from itself, whilst if exposed to the full rush of the under-cooled steam this jacket will be swept away and a larger number of low-temperature molecules will reach the surface of the film. The rate of evaporation from the film depends solely on its own temperature and on nothing else. The film will continue to increase in thickness and rise in temperature until a stage is reached at which the number of molecules evaporated in unit time is equal to the number condensed. The number condensed depends mainly upon the pressure of the surrounding vapour, so that the temperature indicated by a thermometer immersed in supersaturated steam corresponds rather to the pressure of the surrounding steam than to its temperature.

One objection may fairly be raised against the idea that there is any large degree of undercooling in a turbine exhaust. In some highly interesting experiments made with nozzles discharging into the open air, Dr. Stodola showed that once condensation commenced it proceeded with extreme rapidity. The droplets observed by him in his jets of undercooled steam were formed in a period of time of the order of $\frac{1}{10,000}$ of a second, whilst the time occupied by steam in flowing through the low-pressure end of a turbine is some 100 times as great.

It is, however, of first importance to note that the occurrence of condensation or even its completion does not necessarily imply the simultaneous establishment of thermal equilibrium. In fact, strong reasons can be advanced in favour of the view that there is a sensible lag between the two. Indeed, were it not for this, it is difficult to see how the droplets could be built up with anything like the rapidity observed in Dr. Stodola's experiments. Each molecule as it condenses liberates energy, sufficient to raise its own temperature by some 500 deg. to 600 deg. C.,* and were this energy immediately and wholly transformed into heat it is difficult to see how the temperature of the surface could be kept low enough to permit of the building up, by further condensation, of the droplets observed by Dr. Stodola. There are, moreover, other reasons for scepticism as to the instantaneous conversion into heat of the energy liberated on condensation. When two gases combine chemically to form a compound, experiment has shown that the rate of radiation is much greater during this act of combination than it is from a molecule of the compound gas raised by external heat to the same temperature. According to Smithells† "the initial phase of the formation of the new molecule is a vibratory one," and heat only appears on the subsequent damping down of this vibration. The combination of two atoms to form a compound is brought about by electrical forces and at the moment of combination, the energy liberated appears to take the form of vibrations or other motions of the "valency" electrons. A moving electron is the one known source of radiation and at the moment of combination of two atoms this radiation is extremely intense. Moreover, the British Association Committee on Gaseous Explosions point out that in spite of the great density of the gases within the explosion vessels used by them, the gas was remarkably transparent to these radiations, or in other words the molecules surrounding the combining atoms picked up but slowly the energy radiated from them.

Just as the forces holding a chemical compound together are electrical in character, so, too, are those responsible for the attraction between molecules of the same substance to which the phenomenon of liquifaction is due. There are thus good grounds for believing that the energy liberated on the condensation of a vapour is also at the outset represented by electrical disturbances and is only somewhat gradually converted into the form of heat.

There is, moreover, some very direct evidence in favour of this view. Mr. Wilson, in his classical paper in the Philosophical Transactions for 1897 (vol. 189, page 305), observed that if the expansion of his dust-free vapour was just sufficient to produce condensation the number of droplets formed was of the order of 10^8 per cubic centimetre, but that this number increased very rapidly if the range of expansion was increased. The bearing of this observation seems to have been overlooked. It affords direct proof that the additional condensation took place on new nuclei, and the temperature of the vapour must accordingly have been far below the equilibrium value during the whole range of the expansion. The time taken for the expansion in Wilson's experiments was estimated at something over $\frac{1}{150}$ of a second and was thus of the same order as the total time taken for steam to pass completely through a modern steam turbine, and the inference is unavoidable that the steam as finally discharged from such a turbine is still in a greatly under-cooled and supersaturated condition.

An obvious explanation of Wilson's result would be that the time taken by the expansion was too short to permit of any appreciable amount of condensation occurring until the end of the stroke. In that case the steam would, throughout the whole range of its expansion, be practically completely supersaturated and follow exactly the same laws as if superheated. As will be shown in the sequel this hypothesis accords far better with actual experience with turbines than the usual assumption that with wet steam the expansion is effected in conditions of thermal equilibrium. The hypothesis, is, however, untenable in view of the fact that Dr. Stodola's droplets were formed in about $\frac{1}{10,000}$ of a second. Condensation must, therefore, occur when the expansion of supersaturated steam is pushed beyond the Wilson limit, but as we have indicated above, this does not necessarily imply that thermal equilibrium is simultaneously established, and Wilson's observation above quoted shows that the expansion continues with a vapour temperature far below that which would be indicated by any thermometer immersed in it.

On the other hand, pointing to a different conclusion, we have the extremely ingenious experiments of Dr. Stodola which were described in ENGINEERING, January 15, 1915, page 81. Recognising the impossibility of measuring the true temperature of supersaturated steam by means of a thermometer, Dr. Stodola endeavoured to find the specific volume of the steam discharged from a nozzle by estimating its velocity from the reaction observed and then employing the equation

$$v\,\Omega = \mathrm{V}\,w$$

where v denotes the velocity of flow, Ω the area of the nozzle, V the specific volume of the steam, and w the weight discharged per second.

From his observations he deduced the conclusion that the under-cooling of the steam after a twenty-fold expansion did not exceed $\frac{3}{4}$ deg. C., or 1·4 deg. F. This figure, it will be noted, is much less than the defect of temperature often observed in a turbine exhaust pipe, an ordinary thermometer being used which, as pointed out above, will always read too high when immersed in supersaturated steam. Moreover, for condensation to occur on the Wilson nuclei the temperature of the steam must be very many degrees below the saturation value and, as pointed out above, Wilson found that with increasing expansions the corresponding additional condensation came down on new nuclei. It seems impossible to reconcile this observation with Dr. Stodola's results, since condensation only occurs on the Wilson nuclei when the defect of temperature is measured not by $\frac{3}{4}$ deg. C. but by tens of degrees.

The writer will endeavour to show in this series of articles that if his interpretation of Wilson's results be accepted, both superheat and vacuum corrections can be rationalised, whilst the contrary view involves wide discrepancies between theory and practice.

Reliable and consistent steam tables are a prime necessity for such an investigation as is purposed, and the publication in 1915 of "The Callendar Steam Tables" has been of inestimable service in this connection. Most of the calculations made in the course of this inquiry have been based directly on these tables. The processes adopted, however, will probably be more readily followed by most readers with the aid of the steam chart reproduced on Plate I.

Until Professor Callendar took up the matter, the formulas used to represent the properties of steam were wholly empirical and were very commonly mutually inconsistent. Thus the values deduced for the specific heat of superheated steam from the experiments of Knoblauch and Jakob and adopted as the basis of certain well-known tables are quite inconsistent with the specific volumes of the steam also given in the same tables, the discrepancy being as much as 20 per cent. Callendar's formulas have, on the other hand, been deduced from considerations of the physical nature of steam and the known laws of thermodynamics. Their form has been fixed by theoretical considerations, and the coefficients only, determined by experiment. All the formulas are mutually consistent with each other and agree with the only reliable experimental data so far available. In preparing the chart Callendar's formula for the isentropic expansion of steam was employed, viz. :

$$p^{-\frac{1}{13}}\,\mathrm{T} = \text{constant}.$$

where p denotes the absolute pressure of the steam and T the absolute temperature. Starting with high-pressure steam at a given entropy, the absolute temperature attained on expansion to a lower pressure was calculated from the above equation. The corresponding heat content at this lower pressure was then determined by Callendar's equation for the total heat of steam, which in pound-Centigrade units is :

$$\mathrm{H} = 0.47719\,\mathrm{T} + 464 - \frac{144}{1400}\cdot p\left(\frac{13}{3}\times 0.4213\cdot\left(\frac{373.1}{\mathrm{T}}\right)^{\frac{13}{3}} - 0.01602\right).$$

At least seven points were calculated for each curve represented on the diagram. The computations were made with five-figure logarithms and checked by examining the differences. This test led to the detection of a few small isolated errors, which were duly corrected. The calculation was made to five figures and the plot to four figures, on a scale about three times that of the reproduction. This reproduction was made by photography in order to avoid possible errors in copying the curves. The curves were drawn by means of splines suitably adjusted to pass through the plotted points.

One innovation which is thought to be of importance is that the abscissæ values are not values of the total heat H but of 2·2436 (H — 464) As a result, specific volumes can be obtained from the diagram with great accuracy.

It is merely necessary to divide the abscissa reading by the pressure, and to add the constant 0·0123. For example, the abscissa reading corresponding to 90 lb. and 240 deg. C. is 536·65. Hence the specific volume is :

$$\frac{536.65}{90} + 0.0123 = 5.962 + 0.012 = 5.974.$$

The value given in Callendar's tables is 5·9741.

The adiabatic heat drop is measured in the same way as with the ordinary Mollier diagram. The Wilson line shown on the diagram represents the limit to which steam originally dry or superheated can expand without condensation occurring. The method used in deriving it will be set forth in a later issue, to which also will be deferred a description of the two diagrams of reheat factors.

It has long been recognised that the benefit derived from superheat is far and away in excess of what can be accounted for on the hitherto accepted theory of the steam turbine. This acknowledged fact has commonly been accounted for on the hypothesis that with moist steam the frictional losses in the ports and passages of the turbine were very much greater than when the steam was superheated. This "commonsense" view of the matter is extremely plausible, but unfortunately accords very badly with certain well-established facts. In the first place, the gain due to superheat is a little higher the higher the efficiency of the turbine. With a high efficiency, however, the superheat is lost at an earlier point

* No note is here taken of the fact originally established by Lord Kelvin that any molecule that remains in the surface film of a liquid after condensing only parts with about one-half of its total latent heat, the residue being represented by the energy due to surface tension. Maxwell's "Heat," page 291.

† *Encyclopedia Brit.*, vol. x, page 472. See also "Third Report of the British Association Committee on Gaseous Explosions." ENGINEERING September 16, 1910, page 417.

in the steam path, and the proportion of the turbine traversed by wet steam is substantially greater than when the efficiency of the machine is low. Hence the gain due to superheat should, on the hypothesis of a greater friction with wet steam, be higher in the case of a low efficiency turbine than in that of one with a high efficiency. The contrary appears, however, to be the case. Moreover, as Osborne Reynolds pointed out many years ago, the head lost in fluid friction is at high speeds of flow almost independent of the nature of the fluid, being much the same for treacle as for water, and this result is in full agreement, as Professor C. H. Lees has shown, with the very elaborate experiments on pipe friction made at the National Physical Laboratory. The hypothesis that the anomaly in superheat corrections is to be attributed to the higher frictional resistance experienced by wet steam seems therefore untenable,

A study of these anomalies obviously affords the best prospect of determining the actual condition of the steam whilst expanding in the unstable equilibrium which represents the condition of the expanding steam once it has lost its superheat, and the writer proposes accordingly to examine this matter pretty exhaustively.

(To be continued.)

THE CUNARD NATIONAL SHELL FACTORY.

FROM time to time we have illustrated several of the more important shell-making factories throughout the country, and in dealing now with the factory for the manufacture of shell, organised by Sir Alfred Booth, Bart., chairman of the Cunard Company, and Mr. A. D. Mearns, general manager, we make this extenuating explanation that it is important that the patriotic work of this company, not only in connection with the transport of troops and war material, but with the addition to our war supplies, should be fully recognised. Engineers will be specially interested to note that most of the lathes and other machine tools installed in the shell factory were of the ordinary type, suitable for marine work, so as to lessen the demand on specially designed shell-making plant, and to be utilisable after the war in connection with the repair of the ships of the fleet. These machines were converted into shell lathes, and great ingenuity was exercised by the company's engineering department in adapting them for this purpose. Fittings for adaptation of lathes, the erection of all plant, motors, shafting, and accessories, and the making of the tools and gauges used in the factory were all carried out by the staff.

The engravings and drawings (showing the adaptation of these machines for special work) which we are enabled to publish, will be studied with very great interest, because of the high quality of engineering ingenuity which they display. A proof of their success is to be found in the fact that the shells, ranging up to those of 8 in. in diam., have been, and are still, completed entirely by female labour. This was the first factory in Great Britain to manufacture 6-in. and 8-in. shells with female labour, and it thus pioneered the employment of women on shells of large calibre. To enable this to be done special attention was given to the lifting appliances provided, so that women were able to handle the shells at all machining operations without any help. Some of the engineering officers of the Cunard ships who had retired, readily returned to engineering work, in order to help the country in increasing the output of projectiles. In the efficiency of their work is found further proof of the fact that engineers generally, and particularly sea-going engineers, have a training which makes them most adaptable to all manufacturing processes.

The building used for the manufacture of shells, before being converted into a shell factory, had served as a store for fittings and furniture taken from ships which had been transferred from passenger service to the naval fleets as armed cruisers. A new floor was built to carry the machinery for 4.5-in. shells, and the roof trusses were strengthened to carry line shafting. The building, too, has been extended from time to time, in order to increase the volume of production. On Plates II to V we give a series of illustrations of the factory, prepared from photographs, and these may here be briefly referred to, as a preliminary to a detailed description of the successive operations in the manufacture of the shells of the respective sizes, in order to describe the necessary adaptations of the ordinary engine lathes utilised. Fig. 1 is a view of the yard for the reception of raw material, while Fig. 2 shows the interior view of the front shop; the upper floor is for the production of 4.5-in. shells, the middle floor for 6-in. shells, and the ground floor for 8-in. shells. Fig. 3 is a general view along the north side of the top floor, and Fig. 4 is a view on the ground floor. Fig. 5, on Plate III shows the intermediate floor, where 6-in. shells are made, and prominent are the improvised lathes for successive operations, of which drawings will be given and described later. Fig. 6 is a view on the other side of the same floor, where the girl operatives are engaged in finishing the body and profiling 6-in. shells. Special note should be taken, in this view, of the arrangement of cranes on the lathe bed for manipulating the shells. Later we shall give drawings of one of those cranes. The other two views on Plate III show the departments for inspecting the shells. This work is done in an annex to the main building. Fig. 9, on Plate IV, represents the paint shop, while Fig. 10 is a view of one of the earlier processes, and shows the arrangement of one of the furnaces and presses for nosing up. The other views, on the same plate, are illustrative of the 8-in. shell department, where all the lathes were improvised, Fig. 11 being a general view of the department, while Fig. 12 shows the rough and finish boring of the interior of the shells in progress, the boring bar shown being one of a number made from the piston-rods of the liner "Lucania." On Plate V there is a series of illustrations of special operations. Fig. 13 illustrates the drilling and cupping of the noses of the 4.5-in. and 6-in. shells. Fig. 14 shows a combination lathe for rough and finish boring 6-in. shells. Fig. 15 shows the method adopted of hydraulically pressing the copper band on the 8-in. shells, while Fig. 16 illustrates a lathe adapted for parting the shell to approximate length.

In dealing more in detail with the successive operations, with a view of describing the adaptation of the ordinary engine works machine tools for the special purposes of shell manufacture, we may deal first with the 4.5-in. and 6-in. shell. The first operation consists in parting the projectile to approximate length. The rough billet is secured in a worm-driven chuck, and the surplus metal parted off, so that the depth from the bottom of the bore to the mouth of the shell is standardised. The next procedure is to centre the base end from the bore. For this purpose there is bolted to the face plate of a lathe a flanged expanding self-centreing mandrel, an actuating rod passing through the axis of this mandrel and the lathe hollow cone spindle. On the mandrel end of the rod a cone piece is attached, that bears on three collets, which are expanded by hand wheel or quick-motion nut working on an actuating rod, the end of the lathe spindle taking the thrust. The forging is slipped on the mandrel and the collets are expanded. A drill is fixed in the lathe tool holder and as the forging revolves the drill is fed into the solid base of the shell, thus obtaining an accurate centre.

For the third operation, rough-turning the body, there is screwed on the lathe cone spindle a self-centreing chuck having three scrolls or curved inclined planes running from the axis to the outer edge. Three hardened-steel dogs operate in these scrolls, being kept in position by the end plate secured by a tap bolt. The open end of the shell is placed into the chuck, and the fast head-stock centre brought up into position. The chuck is self-acting, the heavier the cut the more positive the grip. This arrangement we shall illustrate in connection with the making of larger shells. By this method, a shell can be rough-turned in one cut, there being no undue friction on the thrust collars of the lathe, which causes great loss of power; this method of drive, therefore, has a distinct advantage over the tapered and fluted design.

The fourth operation is the rough and finish boring of the projectile. Fig. 17, on page 4, gives the dimensions before and after "bottling," and Fig. 18 illustrates the boring bars. The shell is placed in a self-centreing collet chuck, having a locating valve seat at bottom, and steadyments of ample surface. This operation is split up into six distinct parts, six tool holders being fitted in a round turret on the lathe saddle. Firstly, the parallel part of the bore is trued up to almost finished diameter by two side tools fitted in a stiff bar, one tool leading the other by $\frac{1}{16}$ in. Secondly, cutter No. 2 shapes out the bottom of the bore. Thirdly, No. 3 cutter finishes the bottom of the bore to the exact form, and polishes it. [It should be noted that cutters Nos. 2 and 3 do not touch the walls of the shell.] Fourthly, cutter No. 4 faces the mouth of the shell to the required depth of bore. Fifthly, No. 5 cutter finishes to the required diameter of the bore, and blends the walls of the shell to the bottom radius, but does not reach the bottom of the bore. This method was found to be exceedingly successful in obviating pocketed bore, which is usually caused by the finishing diameter cutter staggering when reaching the bottom of the bore, owing to slackness in the lathe saddle, spring in the bar, or the centre of cutter being out of truth. Sixthly, cutter No. 6 chamfers the mouth of the shell to the required form for bottling (see Fig. 17).

The fifth operation consists in facing the base to a high limit of thickness. The shell is placed in a self-centreing collet chuck, and the surplus metal removed from the base end, a standard dimension from the bottom of the bore to the base of the shell being obtained. The sixth operation is the re-centreing of the base end from the finished bore. For this purpose a flanged solid mandrel, relieved to give a bearing surface only at the form of the bottom of the bore and the mouth of the shell is secured to the lathe face plate. The shell is placed on the mandrel, and a drill that is fixed in the tool holder is brought into contact with the base of the shell, and as the mandrel revolves, an accurate centre from the bore is obtained. To avoid any difficulty of the shell becoming fast on the taper, the mandrel is screwed and fitted with a nut, the face of which can be brought to bear against the mouth of the shell, thus forcing the shell free.

The arrangement and details for the rough nosing of a 4.5-in. shell on a Denham engine-lathe, is shown in Fig. 19. The attachment is fitted to an ordinary screw-cutting lathe for rough-radiusing the nose end of the shell (loose nose type) before the fitting in of the nose, thereby taking the heavy work off the former plates at a later operation when the shells are finished turned on the profile lathes. A cast-iron curve plate is fitted between the shears of the lathe bed and a roller bracket is attached to the saddle in such a manner as to enable the operator to work up to the curve plate, the roller preventing too much metal being taken off the nose end of the shell. Before fixing the curve plate, the position of the cutting tool must be taken into account.

For the seventh operation, the "bottling" of the nose end of the shell, the open end of the latter is placed in a gas furnace (Fig. 10), and brought to a straw-coloured heat, care being taken that the intense heat does not creep more than 4 in. down the shell, and that the line of heat is kept at right angles to the axis. The temperature and even diffusion of heat affect the depth of the fuse hole, and the shape of the internal contour when bottling. (See Fig. 17.) The heated shell is now placed in a hydraulic press (Fig. 10), and the mouth pressed to the required form by a pressure of 1,500 lbs. per sq. in. When installing the plant, it was decided to fit air blowers, gas injectors and regulators, whereby both gas and air could be mixed in the required proportions, and passed into the furnaces under pressure. This system proved a great success, a furnace temperature of 1,400 deg. C. being easily maintained with a moderate gas consumption. The cutting out of the usual high-pressure air compressor meant a saving in upkeep expenditure. An improvement was made in the design of the gas nozzles, after which equal temperature in all furnaces could be obtained.

Boring, facing and tapping the fuse hole is the next—the eighth operation. The shell is placed in a lathe fitted with a round turret on a saddle with boring bars, &c., and self-centreing chuck (Fig. 20). The fuse hole is rough-bored, then faced to the depth

THE CUNARD NATIONAL SHELL FACTORY.

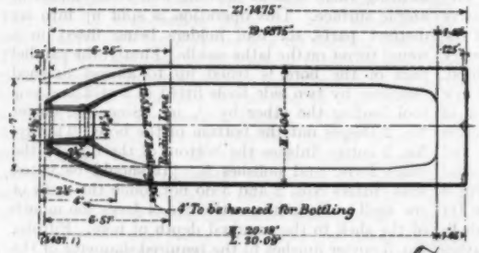


Fig. 17.

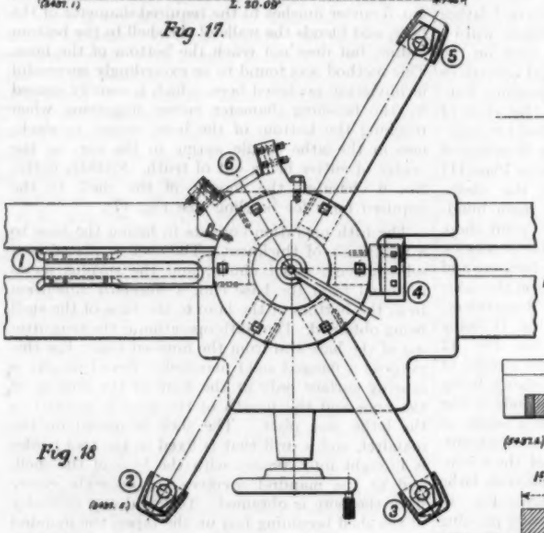


Fig. 18.

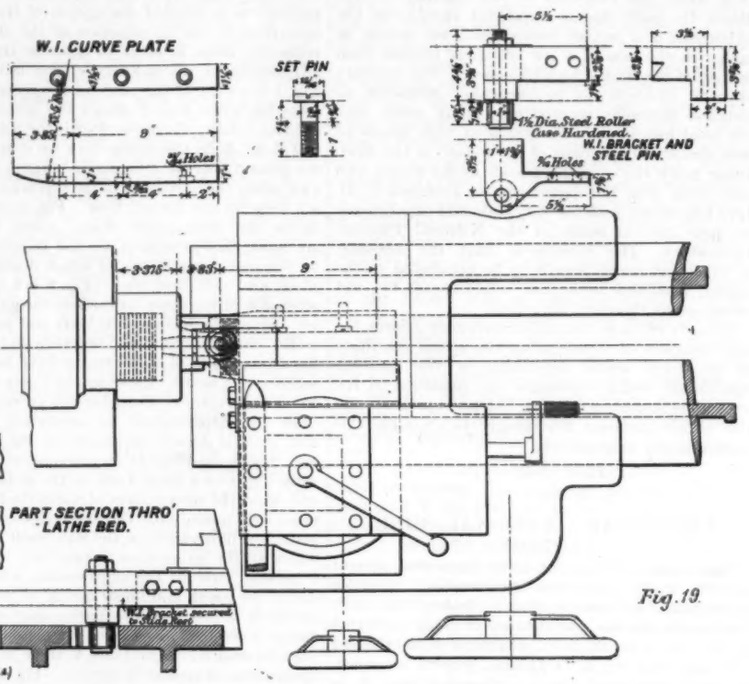


Fig. 19.

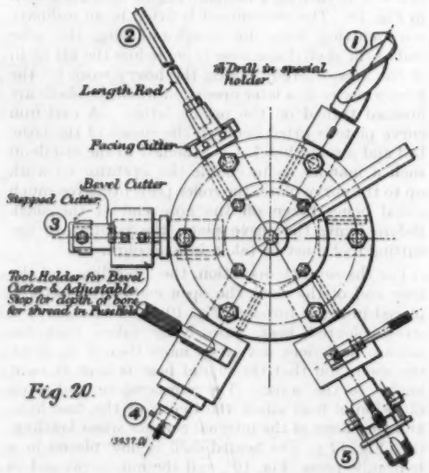

Length Rod
Facing Cutter
Bevel Cutter
Stepped Cutter
Tool Holder for Bevel Cutter & Adjustable Stop for depth of bore for thread in Fuse Hole

Fig. 20.

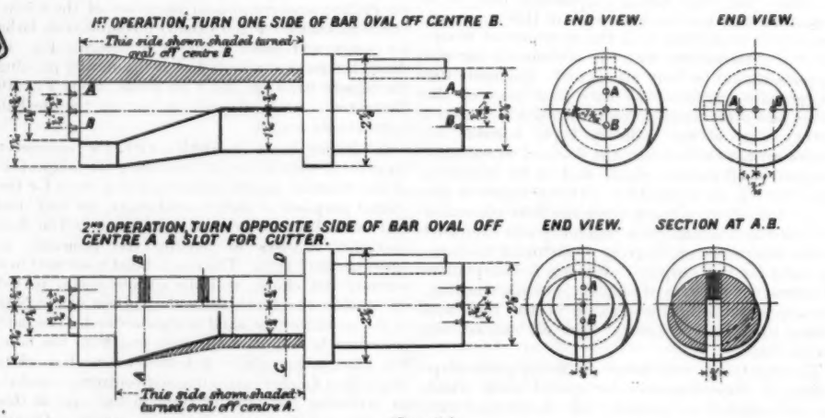

1st OPERATION, TURN ONE SIDE OF BAR OVAL OFF CENTRE B.
This side shown shaded turned oval off centre B.
END VIEW.
END VIEW.
2nd OPERATION, TURN OPPOSITE SIDE OF BAR OVAL OFF CENTRE A & SLOT FOR CUTTER.
END VIEW.
SECTION AT A.B.
This side shown shaded turned oval off centre A.

Fig. 21.

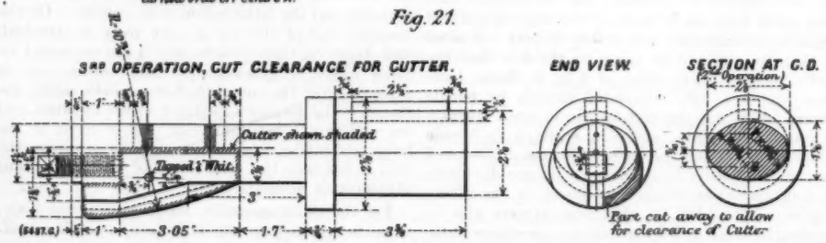

3rd OPERATION, CUT CLEARANCE FOR CUTTER.
END VIEW.
SECTION AT C.D.
Cutter shown shaded.
Part cut away to allow for clearance of Cutter

FIG. 17. DIMENSIONS OF 6-IN. SHELL BEFORE AND AFTER BOTTLING. FIG. 18. BORING BARS, TOOLS, &C., FOR BORING SHELL SHOWN IN FIG. 17. FIG. 19. ARRANGEMENT FOR ROUGH NOSING 4.5-IN. SHELL ON DENHAM LATHES. FIG. 20. BARS AND TOOLS FOR MACHINING 4.5-IN. AND 6-IN. SHELL NOSE-ENDS AFTER BOTTLING. FIG. 21. SCRABBING BAR FOR BLENDING BORE OF BOTTLE-NOSE SHELL FOR NOSE ADAPTER.

of the bore, standard depth being obtained by means of a distance-rod fitted in the end of the facing-bar. A combination tool and bevelling bar then bores to size for the thread and exploder container ring and also bevels the nose end of the shell for the fuse seating. The undercut at the back of the thread is obtained by an eccentric recessing tool bar, which also standardises the depth of the fuse hole between the bevel and the container ring. The fuse hole thread is machined by a collapsible "Murchy" tap fitted in a special floating safety tap holder.

The ninth operation is the "scrabbing" and blending of the internal contour to the bore of the shell. In this case, the shell is again centred from the outside diameter. A special bar (Fig. 21) designed to give rigidity and strength, and also to back up and support the cutter, is fixed in the lathe turret, and is passed through the fuse hole to a given position when the cross traverse feed is fed by hand until the bar rubs against the container ring. A blending tool (Fig. 22) is then brought into operation, the cutter being shaped to the required contour of the shell, and is made adjustable to compensate for wear. A holder secures the bar by a tapered pin, which is easily withdrawn. The bar with the cutter is placed inside the shell by hand, the lathe saddle with the holder being then brought up into position, permitting the tapered pin to be inserted, thereby securing the bar to the holder. The excess metal below the exploder container ring is removed by the cross feed being adjusted and the saddle worked back to a gauged position, thus obtaining correct internal contour. The lay out of the tools for blending is shown in Fig. 23.

Alternatively, operations eight and nine may be combined. The shells are faced to standard depth of bore by means of a distance rod fitted in the end of the facing tool holder, then bored to tapping size with a double-sided cutter fitted in the short, stiff, boring bar. This diameter of hole will now permit special scrabbing bar with the internal form cutter to enter, this tool removes all surplus metal below

THE CUNARD NATIONAL SHELL FACTORY.

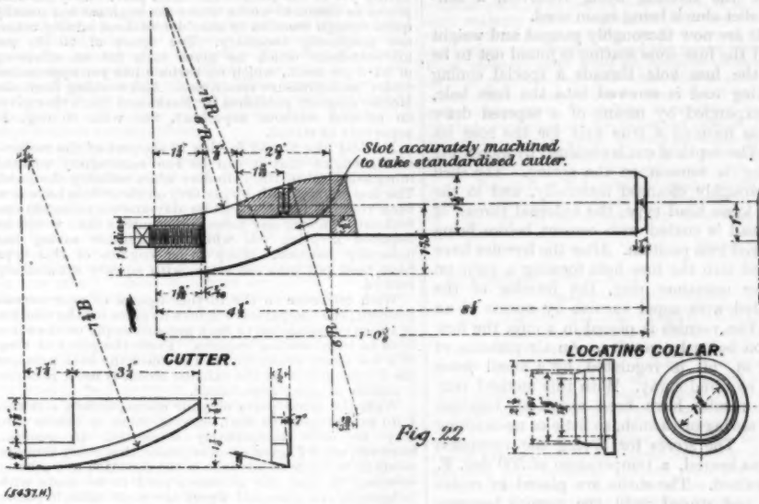


Fig. 22.

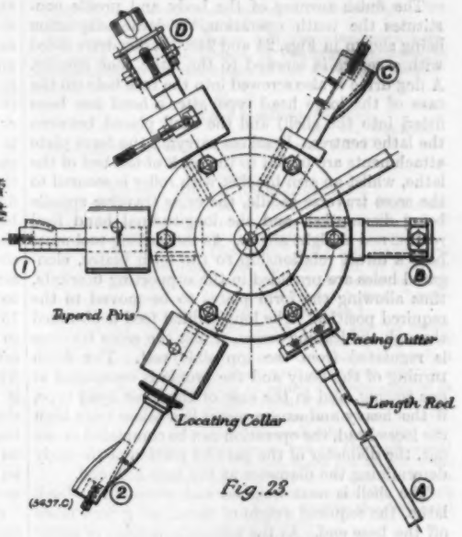


Fig. 23.

VIEW LOOKING ON BACK OF LATHE.

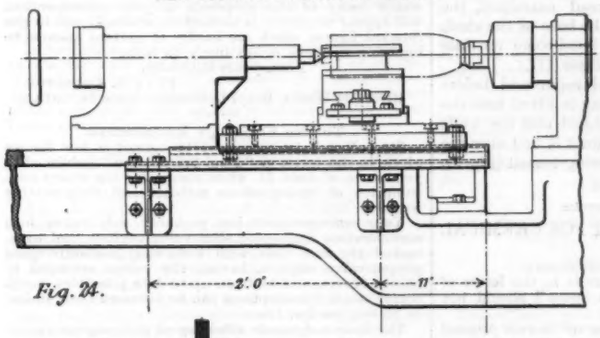


Fig. 24.

CROSS SECTION OF BED OF LATHE.

Fig. 24a.

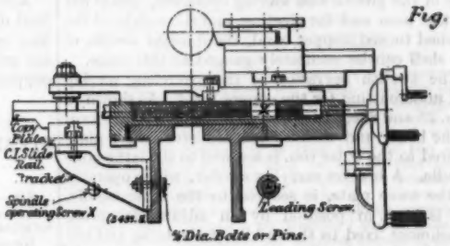


Fig. 24b.

PLAN

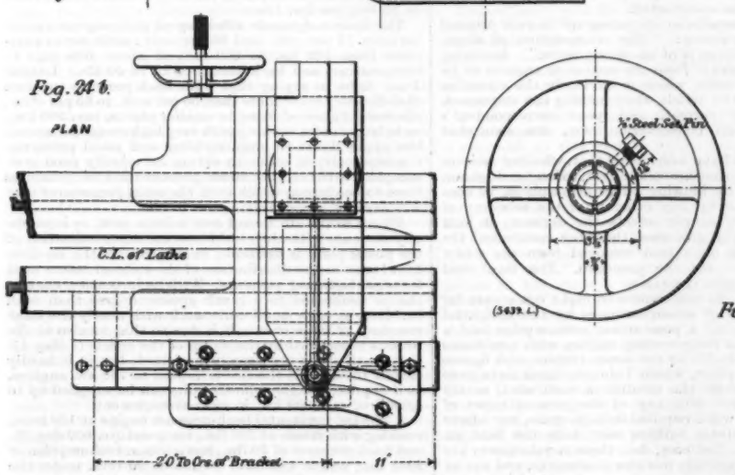


Fig. 25.

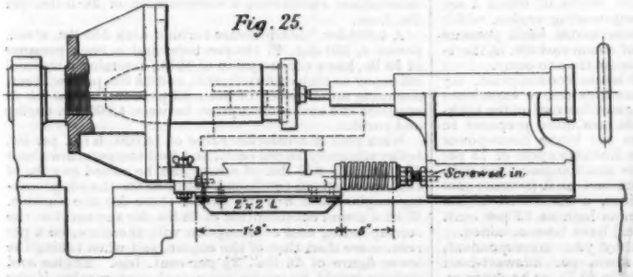


Fig. 26.

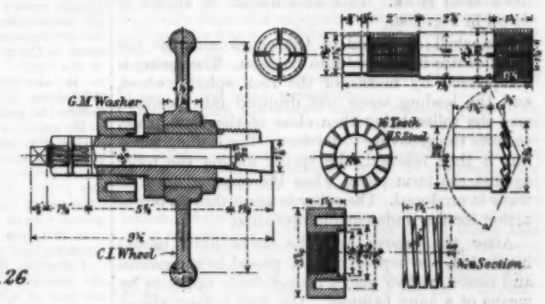


Fig. 25a.

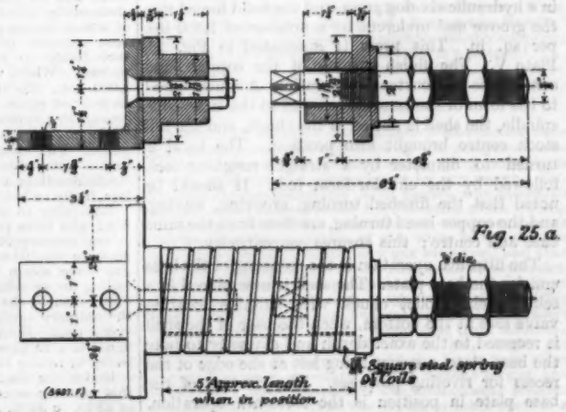


FIG. 22. TOOL BAR FOR BLENDING BORE OF 6-IN. SHELL NOSE-END AFTER BOTTLING. FIG. 23. TOOLS FOR FACING, LINING, BLENDING AND SCREWING END OF SHELL TO TAKE ADAPTER. FIGS. 24, 24a, AND 24b. ARRANGEMENT OF GEAR FOR PROFILING 4.5-IN. SHELLS IN ORDINARY LATHE. FIGS. 25 AND 25a. WAVING SERRATION GEAR FOR 6-IN. SHELLS. FIG. 26. SPECIAL CONING AND RECTIFYING TOOL; SPRING-LOADED NOSE BIT FOR FACING NOSE END OF 6-IN. SHELLS.

the required depth of the thread and also obtains the required internal contour. The thread to take the adaptor is machined by a "Murchy" collapsible t p fitted in a special floating safety tap holder. This alternative is also illustrated by Fig. 21, on page 4, and Fig. 23, on pag 5.

The finish turning of the body and profile constitutes the tenth operation, the lathe adaptation being shown in Figs. 24 and 24*a*. A dog drive fitted with a centre is screwed to the lathe cone spindle. A dog drive is also screwed into the fuse hole (in the case of the loose head type, after a head has been fitted into the shell) and the shell placed between the lathe centres. Brackets carrying the form plate attachments are bolted to the back of the bed of the lathe, whilst an arm bracket with roller is secured to the cross traverse saddle, the cross traverse spindle being dismantled, and the longitudinal hand feed rest turned at right angles. As the cutting tool must bear a direct relationship to the form plates, elongated holes are provided in the supporting brackets, thus allowing the form plates to be moved to the required position. The longitudinal feed is obtained through the leading screw, whilst the cross traverse is regulated from the top slide rest. The finish turning of the body and the profile is completed at one setting, and in the case of the loose head type, if the heavy and excess metal has taken from been the loose head, the operation can be completed in one cut, the diameter of the parallel portion of the body determining the diameter at the fuse hole end.

The shell is next weighed and placed in a chuck lathe, the required weight of metal being then faced off the base end. As the following weights of metal remain constant: metal removed during the formation of the groove and waving operation, metal left on the base end for riveting, and the weight of the finished turned copper band, the finished weight of the shell can be accurately gauged at this stage.

The twelfth operation is the grooving, waving and undercutting for the copper band. As shown in Figs. 25 and 25*b*, a cast-iron chuck, bored to the form of the head, and with a hardened steel wave plate secured to the outer rim, is screwed to the lathe-cone spindle. A bracket carrying a roller, which operates on the wave plate, is secured to the lathe saddle, and is kept in position by an adjustable spring attachment fixed to the saddle of the lathe and the loose head stock. This attachment is shown in detail in Fig. 25*a*.

The shell is placed in the chuck and the tail stock centre is screwed into position. The spring is compressed by means of the rack, spindle wheel, and the leading screw nut dropped into position, and the roller being then clear of the form plate, permits the grooving to be done. The leading screw nut is then released, the spring forcing the roller against the form plate, when the required form of wave is produced. The roller is again thrown out of action for the undercutting operation.

After the groove and the wave have passed inspection, the copper band is placed in the groove and closed at two places diametrically opposite by means of a hand hammer. The shell is then placed in a hydraulic six-dog press, and the band forced into the groove and undercut by a pressure of 1,500 lbs. per sq. in. This press is illustrated in Fig. 15, Plate V. The finish turning of the copper band constitutes the fourteenth operation. A chuck, bored to the form of the head, is screwed to the lathe-cone spindle, the shell is placed in the chuck, and the tail stock centre brought into position. The band is turned to diameter by a straight roughing tool, followed by the circular-form tool. It should be noted that the finished turning, grooving, waving, and the copper-band turning, are done from the same base and centre; this ensures concentricity.

The fifteenth operation is the recessing of the base end for the base plate. The shell is now placed in a self-centreing collet chuck with suitable locating valve seat at the bottom, when the base of the shell is recessed to the exact depth and diameter to take the base plate, a spigot being left at the edge of the recess for riveting purposes. The riveting of the base plate in position is the sixteenth operation. After the base recess has been inspected, a plain base plate is fitted into the recess and riveted into place by means of a pneumatic hammer held in the tool rest, the shell revolving in a worm-driven chuck. This special machine and worm-driven chuck was designed and made by the staff. The base end is now faced—the seventeenth operation—all signs of the riveting being removed, a self-centering collet chuck being again used.

The shells are now thoroughly gauged and weight checked. If the fuse cone seating is found not to be true with the fuse hole threads a special coning and rectifying tool is screwed into the fuse hole, and then expanded by means of a tapered draw spindle, thus forming a true axis for the rose bit (Fig. 26). The depth of cut is obtained by increasing or decreasing the tension on the spring. The shell is next thoroughly cleansed internally, and in the case of the loose head type, the external thread of the loose head is coated with cement before being finally screwed into position. After the ferrules have been screwed into the fuse hole forming a joint on the exploder container ring, the interior of the shell is coated with copal varnish by means of an air pistol. The varnish is placed in a cup, the flow to the piston being by gravity. An air pressure of 15 lb. per sq. in. is regulated by a small lever to give the required spray. With this method very satisfactory results have been obtained, together with a vast saving of varnish, as little or no draining is required. The stores for drying the varnished shells are gas heated, a temperature of 300 deg. F. being maintained. The shells are placed in crates on bogeys, and stoved until the varnish becomes an amber colour. After the ferrules have been removed, and the fuse hole thread examined, the "nature" mark is stamped on the base of the shell, and the shell is passed into the bond room for final examination. (See Fig. 8, on Plate III.)

After passing from the bond room and before final despatchment, a transit plug is fitted into the fuse hole, the base end is varnished and the walls are painted, whilst a rope grummet is tied over the copper band to avoid damage during transit (Fig. 9).

(To be continued.)

STEAM AND POWER PLANT FOR CHEMICAL WORKS.

TO THE EDITOR OF ENGINEERING.

SIR,—Some of the statements made in the letter of your correspondent "Dum Spiro Spero" should not be allowed to pass uncorrected.

He expresses surprise at the paragraph in your original article where it states: "The consumption of steam per horse-power-hour is of no consequence." Assuming all the exhaust steam from the engine or engines to be used in the processes, which is obviously the intention of the writer of the article when making the statement, it is absolutely correct, and your correspondent's references to coal conservation, &c., are somewhat beside the point.

He appears to have overlooked that, whether reciprocating or rotary prime movers be used, so long as no steam passes to waste by blowing off to atmosphere, in condensing water, or by any other way, the economy of the prime mover simply affects the division of heat between it and the processes, the more economical the prime mover the more heat removed from the steam and the less left for the processes. The total coal consumption remains the same.

Following this, he endeavours to make out a case for the exclusive use of steam turbines by the delightful method of assuming a poor steam consumption and a small size for the reciprocating engine, with conditions abnormally favourable to the steam turbine and figures of steam consumption, which I do not think have ever been attained under the conditions mentioned, or are ever likely to be with any of the present types of turbine. While, when required in large units, say above 2,000 kw., the steam turbine may take the field on account of space, first cost, &c., these requirements are present in comparatively few chemical works, and not at all in any bleach, dye, or print works of which I am aware. The moderate size reciprocating engine, which has a lower steam consumption under back pressure conditions than a similar size of steam turbine, is, therefore, likely to hold its own for some time to come.

Returning to the figures of steam consumption, my firm, who have possibly the most extensive experience in any country of building engines for use under back-pressure conditions of all kinds, are quite prepared to guarantee steam consumptions per brake horse-power calling for an efficiency on the Rankine cycle of 75 per cent., even in the case of quite small engines and with the ordinary conditions of steam and back pressure met every day. With larger engines, a somewhat higher figure can be given, and figures as high as 85 per cent. (referred to the indicated power) have been attained.

Under the conditions given by your correspondent, this means a consumption of steam per kilowatt-hour of 33 lb. to 35 lb. and not 40 lb. to 45 lb. as he assumes. Why he limits the size of the engine, the steam pressure and superheat, I am at a loss to understand. There does not appear to be any particular reason to account for it, as no such limits are met with in practice.

Apart from the fact that steam turbines are not so efficient as reciprocating engines under back pressure conditions, I think it will be conceded that the high pressures and superheats your correspondent proposes, in order to put a good case for the steam turbine are hardly yet in the commercial field, particularly for such places as chemical works where the engineer has usually quite enough troubles to shoulder without adding others not absolutely necessary. The figure of 20 lb. per kilowatt-hour which he gives calls for an efficiency of 84·5 per cent., which no turbine has yet approached under back-pressure conditions. And working from the Mollier diagram published by Marks and Clark this gives an exhaust without superheat, not with 90 deg. F. superheat as stated.

I would like to add further in support of the reciprocating engine that it can be run successfully without lubricating oil in the cylinders when suitably designed. The first engines built by my firm on these lines have now been running ten years under day-and-night conditions without requiring any more replacements than would be required if using oil, while considerable saving has naturally resulted. Many other engines of this type have been put into use since, with equally satisfactory results.

With reference to the further figures of your correspondent, the comparative figures he gives for the relation of steam consumption to back pressure apply on the same lines to reciprocating engines. From the point of view of a low steam consumption, the lower the back pressure the better, but if *all* the exhaust steam is used, it is not a matter of great importance.

With the other parts of your correspondent's letter, I do not propose to deal, leaving them to others who may be more immediately interested. In general, however, while I agree, as an engineer, that every attempt needs to be made to advance in the direction of a greater economy of coal, the advances need to be made with judgment, and chemical works are most difficult places in which to attempt anything which is not cut and dried. To proceed, therefore, too rashly, which is the light in which many of the proposals of your correspondent will appear to others, is to invite a set-back, and to put forward figures which are hardly of judicial fairness to opposing opinions is not likely to help.

I am, yours faithfully,

F. O. L. CHORLTON.

Riverside Works, Bury, Lancashire, June 26, 1918.

TO THE EDITOR OF ENGINEERING.

SIR,—May I be permitted to correct a few figures given in the letter of "Dum Spiro Spero," published in your issue of June 21, when comparing the steam consumption of back-pressure turbines and reciprocating engines.

Your correspondent has probably only taken into consideration high-speed slide-valve engines, and overlooked the fact that with horizontal moderate-speed poppet-valve engines, having the valves arranged in heated covers, and built on up-to-date principles, much better steam consumptions can be obtained than 40 lbs. to 45 lbs. per kw. hour.

The thermo-dynamic efficiency of such engines ranges between 75 per cent. and 90 per cent., with steam pressures from 140 lbs. to 200 lbs., at about 600 deg. F. temperature, and back pressures up to 50 lbs. I think I am right in saying that with back-pressure turbines the efficiency is not more than 50 per cent. to 65 per cent., the lower figure referring to smaller plants, say, 500 kw., or to larger units working with very high steam pressures; the upper figure to large turbines and usual pressures. Consequently, in order to obtain an equally good consumption with turbines, steam pressures and temperatures have to be chosen, which even the most progressive user will avoid if he possibly can.

Where works are spread over a large area, as is generally the case with chemical factories, decentralisation of the power plant is desirable, as this ensures the smallest heat losses in the distribution of the exhaust steam used for manufacturing purposes. With reciprocating engines this is facilitated to a much greater degree than with turbines, as even small units work with nearly the same economy as large ones. It is due to this, as also to the reasons mentioned by the writer of the article of May 17, that small units are usually preferred, but it is hardly correct to say that the size is limited to 750 kw. engines, as if required, single-cylinder units can be supplied up to 4,000 kw. or 8,000 kw. in twin arrangement.

A 750-kw. horizontal back-pressure engine at 150 revs., working with steam at 200 lbs., temperature, 600 deg. F., and back pressure of 30 lbs., has a steam consumption of 30·5 lbs., and a 4,000-kw. engine at 90 revs. under the same steam conditions, a consumption of 28·5 lbs. per kw. hour.

A 4,000-kw. back-pressure turbine with 350 lbs. steam pressure, 750 deg. F. temperature, and a back pressure of 30 lb., has a consumption of 28 lb., assuming a thermal efficiency as high as 60 per cent., and 26 lbs. per kw. hour, assuming an efficiency of even 65 per cent. Now let us compare the coal consumption between 4,000 kw. engine and turbine.

With coal of a calorific value of 14,000 b.t.u. per lb., boiler efficiency 75 per cent., and feed temperature about 180 deg. F., 8·9 lbs. of steam can be raised per lb. of coal under steam conditions assumed for the reciprocating engine, and 8·4 lbs. under those for the turbine. With a steam consumption of 28 lbs. for the turbine, the corresponding coal consumption will, therefore, be 4 per cent. more than that of the engine, and when taking the lower figure of 26 lbs., 3½ per cent. less. Engine and turbine would have the same coal consumption if the turbine consumes 27 lbs. of steam per kw. hour, but even if this were possible, there can hardly be any doubt as to which of the two installations is preferable from the point of view of reliability and cost of maintenance.

With the steam engine, the exhaust has a temperature

of 330 deg. F., whereas the exhaust temperature of the turbine consuming 27 lbs., is as high as 430 deg. F., or the superheat is 55 deg. F. and 155 deg. F. respectively. For heating purposes, highly-superheated steam is certainly not desirable, chiefly because it is not a good heating medium, as also stated in the article in your issue of May 17. If slightly higher exhaust temperatures are required with the reciprocating engine, the initial steam temperature may be raised without fear of carbonisation in the cylinder, provided lubrication is properly arranged and suitable oil used. With correctly-designed valves, also no leakage need occur, with the obvious result of a still better steam consumption, and special superheaters are superfluous.

What appears at first sight the great advantage of the turbine over the piston engine, the absence of lubricating oil in the exhaust, is, on closer investigation, a much smaller asset than might be supposed. There are oil separators in the market which extract oil to within 1 grain per 10 gals. of condensed steam. The lubricating oil consumption of a 4,000 kw. back-pressure steam engine is only 12 grains per h.p. hour, so that only 1½ per cent. of the oil fed into the cylinder remains in the steam, which is almost negligible. In dyeing factories such steam may be brought into direct contact with the fabrics without affecting their quality.

The above remarks apply in a still greater degree to pass-out or extraction engines, and this type of prime mover will take the field if the power demand is in excess of what is obtainable from a back-pressure engine by expanding high-pressure steam down to the required heating pressure (engine acting practically as reducing valve), and if at times no heating steam is used at all. In this connection it may be mentioned that the saving realised with an extraction engine over a high-class condensing engine (about 14 to 15 lbs. per useful kw. hour), and direct heating from boilers is, at least, 20 per cent., if it be assumed that on the average, half of the total steam required would be power steam, and 25 per cent. if one-third is power steam (maximum). If compared with a less economical condensing engine, the result is, of course, still more in favour of a high-class extraction engine.

In conclusion, I venture to observe that it is impossible to establish hard and fast rules on the power equipment of chemical works, as each case has to be treated according to its particular conditions. The subject is also one which commends itself to the attention of the "Coal Conservation Committee."

Yours faithfully,
F. SCHUBELER, M.I.Mech.E. (SULZER BROS.)

TO THE EDITOR OF ENGINEERING.

SIR,—I note from your issue of June 28 that the writer of the article under the above heading appearing in ENGINEERING of May 17, has qualified his statement that "The consumption of steam per horse-power hour is of no consequence," when exhaust steam is used for heating. This qualification is very necessary. The statement, of course, only holds good when the quantity of steam required for heating exceeds the quantity required for production of power, and, I may add, is likely always to exceed.

I have in mind instances of large chemical works, where the amount of steam used for heating was much in excess of that required for power when the plant was first installed, but in course of time the demand for power has so increased, without additional heating steam being required, that the economy of the power plant became a matter of the first importance. Indeed, it should always be so, because if a large quantity of steam is required for manufacturing purposes, as much power as possible should be developed, and any surplus beyond that required in the particular works disposed of elsewhere. Works should co-operate in this way. I note in a recent American technical journal that over there it is proposed that private power plants should be shut down during the summer months, except those which are utilising the exhaust steam for heating, drying or manufacturing purposes, the proprietors of such plants being thus encouraged or constrained to develop the use of their exhaust steam or combine with other businesses requiring steam for heating purposes. Legislation was actually being considered to enforce this.

As to whether a reciprocating engine or steam turbine is best depends largely on the special conditions in each case, but it is a fact that for anything but the largest-sized units, a great deal more power can be obtained from a reciprocator than a steam turbine under back-pressure conditions with a definite quantity and quality of steam, the reasons being obvious, and the higher the back-pressure the greater the advantage in using a reciprocator.

Your correspondent "Dum Spiro Spero" is hardly fair to the reciprocator in stating that the consumption of a reciprocating engine set of 750 kw., with 240 lb. steam pressure, 550 deg. F. temperature, and 30 lb. back-pressure, would be as high as 40 lb. to 45 lb. per kw. I am in a position to state that 30 lb. per kw. should be obtained, and has been obtained, from reciprocating engines working under similar conditions. For many works, a combination of back-pressure engines and condensing engines and live or exhaust steam turbines makes the best arrangement, using devices whereby the load is automatically transferred from the back-pressure sets to the condensing portion of the plant, or *vice versa*, as the demand for steam for manufacturing purposes or for power varies.

3,000 kw. back-pressure turbines are mentioned in conjunction with exceptionally high pressures and temperatures, but whatever may be the position in the future, there are, at present, exceedingly few manufactories in England which could usefully instal back-pressure turbines of that power, and, in the meantime, there are a very large number of manufactories and districts which could utilise plants of various sizes up to 1,000 h.p., to say nothing of the fact that there is a great deal of existing plant of these sizes which can be used.

The fact must not be lost sight of that economy is not everything, and that reliability must always be the first consideration, and in this connection, it is obvious that such extreme conditions as 350 lb. pressure and 750 deg. temperature must involve grave risks of trouble with the boilers, super-heaters, and the power plant generally. Back pressure is in itself an onerous condition for any form of prime mover, and when this is accompanied by other extreme conditions in the way of steam pressure and temperature, difficulties in working may be anticipated, accompanied by enhanced cost of maintenance and risks of stoppages, bearing in mind that a single stoppage of a works may easily neutralise a whole twelvemonths' saving. As such a big gain results from the utilisation of the exhaust steam under quite comfortable conditions, it is a pity to imperil the development of this system of working by resorting to extreme conditions.

Yours truly,
"THERM."

Birmingham, July 3, 1918.

INDUSTRIAL COMBINATION.

TO THE EDITOR OF ENGINEERING.

SIR,—Whilst agreeing with the principle of combination in British industries, I think it is wise for manufacturers to consider very seriously before they attempt to re-construct their present system of distribution to overseas markets through merchant houses.

Any attempt to displace the export merchants with their wonderful and complex system of finely-balanced credit arrangements and their extensive knowledge of shipping and banking, coupled with the huge capital invested by them, is bound to cause nothing but chaos, and would upset Great Britain's commercial relations with every market of the world. What of the importers all over the world? Probably 75 per cent. of their trade is done through export merchants over here, and all their long-established and carefully-conceived arrangements would be swept ruthlessly aside, and the manufacturers have not the experience or the specialised knowledge to fill the gap.

Let industry first organise production, and the altered conditions will, by the natural law of evolution, soon lead the export merchants to get together and organise their end of the business, when they will deal with overseas commerce of the nation more efficiently and more economically than the manufacturers could possibly do.

Yours faithfully,
HOWARD F. SMITH.

Hampton-street, Birmingham,
July 2, 1918.

"DUMPING."

TO THE EDITOR OF ENGINEERING.

SIR,—I have read the communications of "One Who Doesn't Know" in your issues of June 7 and 21. It is regrettable that your correspondent has not given his name, so that we could remove the suspicion—a lurking but certainly a very reasonable suspicion—that our enemies will use all the cunning they are capable of, to secure pre-war conditions.

I believe, due to transit conditions in pre-war time, it was possible to ship coal to the Continent and have it returned to this country at less cost than to send it by rail from the colliery to the consumer. Alterations in our freight charges that will foster home production will result to our advantage, and surely fuel is one of the most essential factors in manufacture. Then why did we give this advantage to the Continent.

"One Who Doesn't Know," when he states that "We have been driven because of our want of foresight and *skill*," is so un-British and incorrect that it proves he has made a mistake in signing his letter—it should read "One That Will Not Know." It requires little brain exertion to remember how hundreds of our skilled men at Woolwich Arsenal were driven into the arms of Germany by their dismissal and inability to secure equal work in our own country. That may be truly termed want of foresight, but on whose shoulders lies the blame? So far as skill is concerned, this war has proved what was patent to everyone who was intelligently observant, namely, that the British mechanic has no superior throughout the world, if any equal.

I could cite many concrete examples of how British brains were harnessed to make our enemies strong, but space forbids this.

In conclusion, let "One Who Doesn't Know" rouse himself, wake up, look round and give one case of want of skill. There are too many whose one aim is ninepence for fourpence, something for nothing.

Yours faithfully,
DAVID A. SHERET, A.M.I.Mech.E.

Enerdale House, Heaton-grove, Newcastle-on-Tyne,
June 24, 1918.

TO THE EDITOR OF ENGINEERING.

SIR,—I am grateful to "Didymus" for trying to help me. This is my difficulty. If only a few industries are to be fostered, it seems to me that others must suffer; but, if *all* our industries are protected, is everybody to pay the cost? Who paid, in America, for protecting the steel makers? I discussed with McKinley himself the proposed tax on tin-plates, which seemed to me to be more likely to injure the exporters of tinned goods than the Welsh manufacturers; and what happened? A rebate of 99 per cent. had to be allowed on all re-exported tin—and Wales did better than ever!

Let it be admitted that I am ignorant and childish and stupid. I am, however, anxious to get at facts, not beliefs; and I know the importance to foreign countries of a surplus of some natural product which we have not got; so who is to pay the cost of protection?

Your obedient Servant,
"ONE WHO DOESN'T KNOW."

June 29, 1918.

TO THE EDITOR OF ENGINEERING.

SIR,—The answer to the question of your correspondent "One Who Doesn't Know," is:—

The foreign manufacturer and the merchants here, who make handsome profits in dealing in articles of foreign make to the detriment of the workers in English manufactories.

I am, Sir,
Your obedient Servant,
W. W. WILKES.

16, Thurlstone-road, West Norwood, S.E.27,
June 25, 1918.

TO THE EDITOR OF ENGINEERING.

SIR,—I have no wish to be involved in a discussion about matters that I do not fully understand, but it occurs to me that possibly the closing of Mr. Dewrance's works mentioned by "Didymus," may not have been entirely due to dumping. Let us, first of all, be clear on one point—"the Germans cut the price below what it cost them to produce." Does the word "them" refer to Mr. Dewrance's firm or to the Germans?

It was my good fortune some years ago to assist English manufacturing chemists in obtaining alcohol at a reduced price for trade purposes. German chemists had had the benefit of a long start with duty-free alcohol—potato spirit—the distilling of which was encouraged in every way in Germany, while British Excise-men formerly collected high taxes and imposed restrictions on output. The relief to our own chemists probably came too late to be of much use in peace times, but no German goods are imported now, and so English firms are selling some drugs at 50 times their pre-war prices. When the war is over, there will again be competition in the world's markets, and then those who can supply the best and cheapest products will win as before!

Yours faithfully,
W. H. MASSEY.

Twyford, Berkshire, July 2, 1918.

PAYMENT BY RESULTS.

TO THE EDITOR OF ENGINEERING.

SIR,—Mr. Isaac Ross suggests that my views concerning the above subject are biased. Let me assure him that, in my opinion, neither party (employer or employee) is beyond reproach, and that it is a great waste of time trying to apportion blame one way or another. My contention is that there is too much pottering and discursive talk on an obvious course. Mr. Ross begins his letter confusing the principle of "Payment by Results" with what is misnamed the "Bonus System of Payment." It should be unnecessary to state that "Payment by Results" presupposes proportionate remuneration for services rendered, and as premiums or bonuses convey the idea of gratuities or payments additional to earnings there is no connection between the terms. Furthermore, Mr. Ross, after more than 25 years' experience, appears still to differentiate between productive and unproductive labour involved in manufacturing. The letter of Mr. Bollinckx is sufficient answer to the latter conception.

Mr. Ramsay has shown that a straight piece-work system, comparing two workers producing the same quantity in 100 hours and 70 hours respectively, gives the employer—in the second instance—an advantage of 100 per cent. improvement (on a 10 per cent. basis of profit calculated on Labour + Oncost — a good average) against an increase of about 45 per cent. to labour. Surely, "Brains" + resultant organisation is fairly and amply rewarded. It might also be shown that the first worker effected a considerable saving over average attainment, and, consequently, the figures given above should be correspondingly increased—probably to the extent of remunerating "Brains" extravagantly.

I may say I did not endorse Ruskin's dictum. What I said was that "If the principle of 'Payment by Results' is acknowledged, it should be straightforwardly adopted; otherwise it is difficult to confute Ruskin's dictum."

Yours faithfully,
W. J. GROSART.

ACETYLENE SILVER.—Contradictory statements have been made about the explosion of the acetylene compound of silver, the decomposition being sometimes merely rapid and not accompanied by any report. Examining the compound, Dr. John Eggert, who presented a paper on the subject to the April meeting of the Bunsen Gesellschaft, found that when there is a report, there is also considerable evolution of gas, while in the absence of a report there is hardly any gas evolution, and that the mode of preparation of the compound is important. The acetylene silver is precipitated when a current of acetylene is passed through a solution of silver, either acid silver nitrate, or ammoniacal silver nitrate; there are other methods. In the former case (acid solution), the compound may give off 17 cub. cm. of gas per 100 milligrams of compound; in the latter case there is generally only one-tenth of that volume of gas, and to obtain a pure compound, the ammoniacal solution should be diluted. When the explosion takes place in a small glass vessel, the walls become coated with soot and silver; these solid particles do not travel far from the flame, however, as Eggert showed by experimenting in glass tubes, up to 1·5 m. in length.

4,000 CUBIC FEET AIR COMPRESSOR.

CONSTRUCTED BY MESSRS. BELLISS AND MORCOM, LTD., ENGINEERS, BIRMINGHAM.

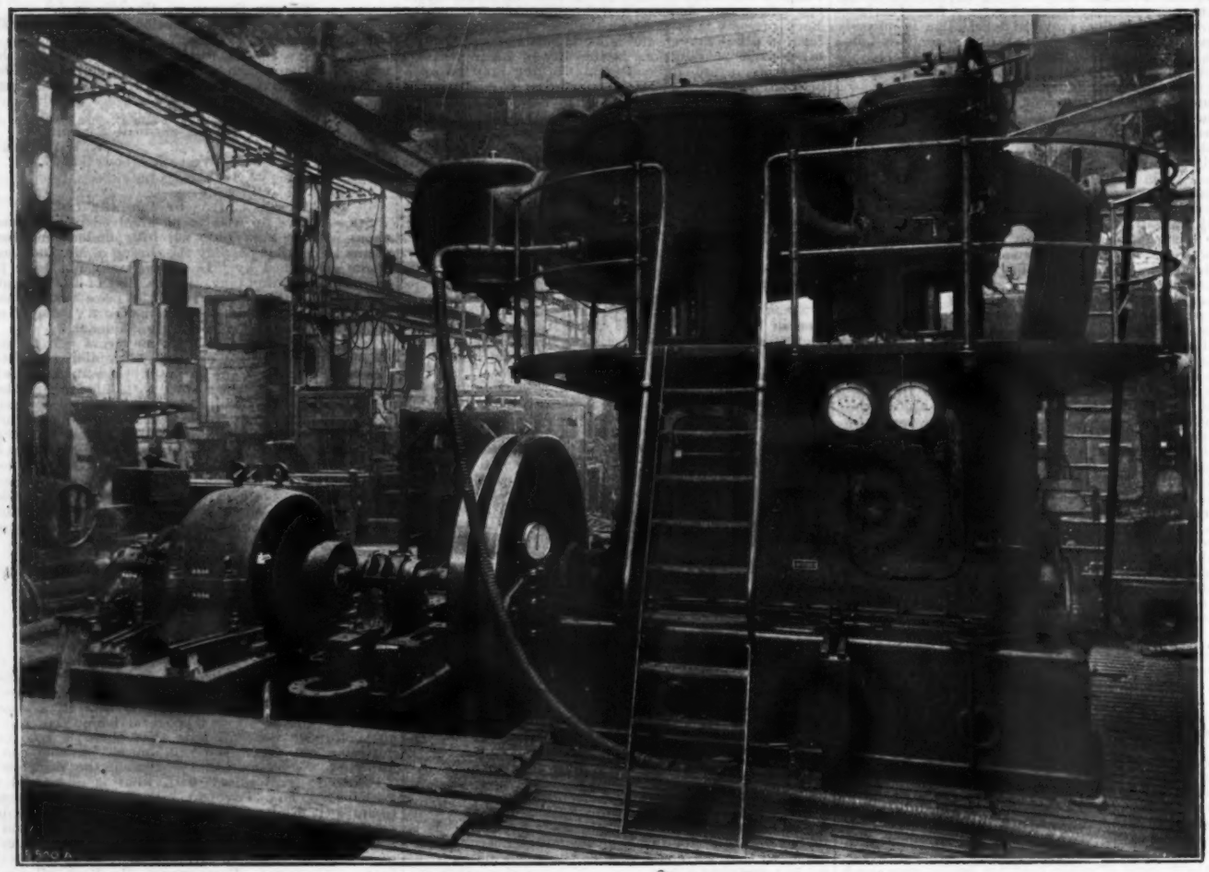


FIG. 1.

TESTING AIR COMPRESSORS.

Some Test Results of a 4,000-cub. ft. Belliss and Morcom Air Compressor.

By N. S. TENNANT, M.Sc.

THERE is considerable diversity of opinion as to the best method of controlling the supply of air from a compressor, and so far as the author is aware, there are little, if any, published data on the results of the various systems, in fact, test figures of any kind on the performance of air compressors are infrequent in technical journals.

The author recently had the opportunity of making some exhaustive tests on one of the four 4,000-cub. ft. air compressors built by Messrs. Belliss and Morcom, Ltd., of Birmingham, to the author's instructions, for a firm of colliery owners, and shown in Fig. 1, above. The results of these tests form the basis of this article.

A compressor is usually required to run for a considerable portion of its time at loads considerably less than full load, depending on the conditions of service. As, in the present case, it is estimated that the compressor will be required to run at an average load of two-thirds of full load, the efficiency at partial loads is a matter of importance, and this will depend on the method of governing adopted.

In the present case the output of air is controlled by a valve at the compressor intake designed to operate intermittently, completely opening and closing as required to maintain a constant air pressure in the receiver. By this method the compressor runs continuously at full load and at its highest efficiency until such time as the demand for air is less than normal, when, on a slight increase in the receiver pressure the intake valve shuts completely and the compressor runs unloaded. Under this condition the first stage air piston runs in a partial vacuum, and in the second stage the air in the clearance spaces is compressed to the discharge pressure and re-expanded to the intake pressure at every stroke. As the compressor runs either at full load, or else at no load, it is evident that the power required to drive the compressor against full air pressure when delivering no air, throws a considerable amount of light on the performance when the air requirements are less than the full output of the compressor.

The compressor in question is electrically driven by a three-phase induction motor running at a constant speed of 243 r.p.m. It is of the vertical, two-stage double-acting type, and is directly coupled to the driving motor. The following are the leading particulars and guarantees given by the makers:—

Makers' No.	1,035.
Capacity	4,000 cub. ft. of free air per minute.
Air Pressure	80 lb. per sq. in. by gauge.
Valves	Rogler Hoerbiger disc pattern.
Piston rings	Rowan's cast-iron.
Lubrication	Forced.
Piston-rod packings ...	U.S.A. metallic.
Brake horse-power input at above capacity	676 b.h.p.
Cubic feet of air per min. per brake horse-power at full load ...	5·92
Brake horse-power required to drive compressor against 80 lb. air pressure when delivering no air ...	54

Full-Load Tests.—As the supply of three-phase power at the makers' works was insufficient to drive the compressor at full load, these tests were carried out by coupling the compressor to a steam engine, indicator cards being taken at frequent intervals. The air compressed was measured by pumping up a receiver of known capacity, a method of testing which is too well known to need recapitulation here.

The author would mention in passing, that he believes equally satisfactory results would be obtained by an air-flow meter, and as this method of testing could be readily applied on the site, continuous records of the performance could be kept. This method is in common use on the Rand, and could be applied in this country with advantage. A considerable number of trials were made and the mean result is as follows:—

Cubic feet of air compressed to 80 lb. gauge per minute	4,120
Brake horse power	655
Cubic feet per brake horse-power ...	6·29

This result, it will be noted, is 6·25 per cent. better than the guarantees.

No-Load Tests.—As the no-load power guaranteed by the makers is 8 per cent. of the full-load power, it was felt that tests made with the driving motor provided with the compressor, which has a capacity of 725 brake horse-power, would not be sufficiently accurate. A 50 brake horse-power direct-current motor, which has a capacity approximately equal to the no-load losses, was therefore obtained, and, after calibration on a Heenan and Froude water brake, was directly coupled to the compressor for the tests. The results of the water-brake tests on the motor are shown in Fig. 2, where the test points showing the relation between the electrical power input and the brake horse-power are indicated by dots, the curve for the mechanical efficiency being based on this relation. In order to obviate any possible error in the electrical instruments, the same instruments were used on the compressor tests as were used on the brake tests of the motor. A diagram of the electrical connections is shown in Fig. 3.

The water resistance shown in the armature circuit was introduced to limit the armature current, thus protecting the motor against over-loads occurring during the tests; some such protection is obviously necessary since it is apparent that if for any reason the air-inlet control valve opened during the tests the full-load torque of the compressor would be applied to the motor.

Under normal working conditions, the compressor required about 50 per cent. of the full-load torque to

start from rest; this, of course, is well within the starting torque of the driving motor, but is equivalent to about seven times the full-load torque of the motor used for the no-load tests. This difficulty was overcome by closing the inlet-control valve and exhausting the air from the compressor cylinders by means of an air pump connected to the compressor-discharge pipe. This air pump produced a vacuum of about 15 in. and practically eliminated the resistance due to the compression of the air, when the motor was found to start readily enough against the remaining resistance in the compressor.

So soon as the compressor reached the normal speed of 243 r.p.m. the air pump was disconnected and the full working pressure of 80-lb. gauge was introduced at the compressor, thus reproducing the normal no-load running conditions. It was found necessary to run for some time before the working temperatures of the motion work, cylinders, and oil in the crank chamber were reached. After about 3½ hours run the temperature of the oil in the crank chamber reached 111 deg. F., and the temperature of the cooling water circulating through the jackets and intercooler reached 73 deg. F., at the outlet. The amount of cooling water in circulation was regulated so as to repeat the temperatures obtained on the full-load trials.

Fig. 2. BRAKE TEST OF MOTOR USED FOR NO LOAD TEST.
Six pole shunt wound with interpole.
Speed, 240 R.P.M.

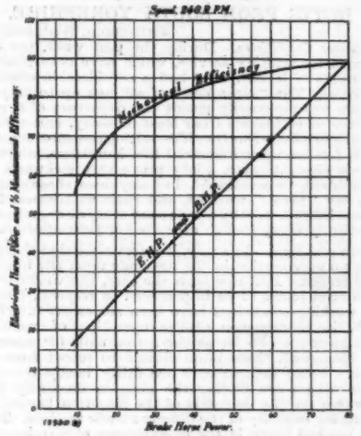
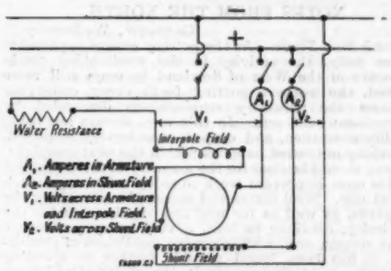
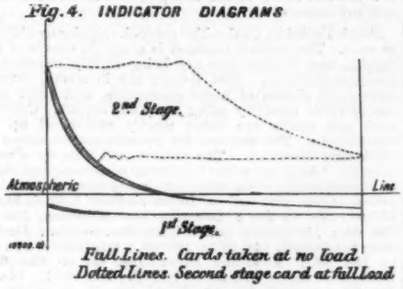


Fig. 3. DIAGRAM OF ELECTRICAL CONNECTIONS TO MOTOR



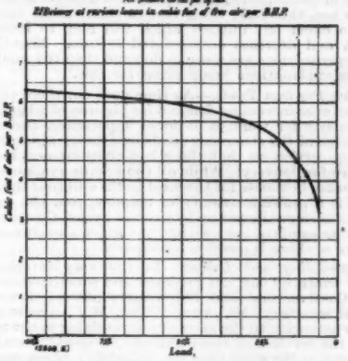
Total Electrical input to Motor $A_1 \times V_1 + A_2 \times V_2$

Fig. 4. INDICATOR DIAGRAMS



Full Lines. Cards taken at no load.
Dotted Lines. Second stage card at full load.

Fig. 5 BELLIS AIR COMPRESSOR No. 1053.
Capacity. 4120 cubic feet of free air per minute.
Air pressure 80 lbs. per sq. inch.
Efficiency at various loads in cubic feet of free air per B.H.P.



The power taken at the commencement of this test when everything was cold, was, as might be expected, appreciably higher than when the normal working temperatures were reached, the maximum power recorded at the start being 47·8 brake horse-power, which gradually fell with the rising temperature to the steady value of 38·2.

The no-load horse-power of 38·2 brake horse-power is 29 per cent. below the guarantee of 54 brake horse-power, and represents 5·64 per cent. of the guaranteed horse-power, which may be compared with 8 per cent. guaranteed. Indicator diagrams taken from the air cylinders are shown in Fig. 4, from which it is evident that the air in the clearance spaces of the second-stage cylinder is compressed to the discharge pressure and re-expanded to the intake pressure at every stroke, the first-stage diagram being almost a straight line lying well below the atmospheric line. It is evident from the indicator cards that the work done on the air is very small, and it is difficult to determine exactly the power indicated by the measurement of such small areas; careful measurements were, however, made, and the power works out to 16 i.h.p., which amounts to only 2·6 per cent. of the total air indicated horse-power at full load.

In addition to indicating the air tightness of the inlet-control valve, the diagrams show that the slip or leakage of air past the air valves is extremely small; for example, the second-stage delivery valves have the full discharge air pressure on them all the time, and any considerable air leakage would have greatly increased the area of the diagram. The temperature of the air at the compressor discharge was measured by thermometer in the discharge pipe close to the compressor, and was found to register no more than 100 deg. F. throughout the no-load tests.

The loss due to mechanical friction alone could be deduced by subtracting the residual air indicated horse-power from the measured brake horse-power input, and using the foregoing figures this amounts to 38·2 − 16 = 22·2 brake horse-power. As a check on this result the air pump was reconnected to the compressor discharge and a vacuum of about 15 in. applied. Indicator cards taken under this condition were straight lines, no area being visible showing that the residual air horse-power had been eliminated.

The input power to drive the compressor was found to be 21·6 brake horse-power, or 3·25 per cent. of the full-load power, a result which is reasonably close to that deduced from the indicator diagrams. The mechanical efficiency of the compressor on the full-load test was found to be 93 per cent., and it appears from the above results that the frictional losses increase from 3·25 per cent. at no load to about 7 per cent. at full load.

Throughout the test the compressor-motion work was lubricated under pressure from an oil pump in the crank chamber driven from an eccentric on the crank-shaft, the pressure being maintained at 26 lb. per square inch. A series of tests were made to see whether a change in the oil pressure made any difference to the power input. The oil pressure was varied from 4 lb. to 45 lb. per square inch, but no appreciable difference was made to the power input. The extra power taken by the oil pump at 45 lb. pressure is estimated at about 0·38 of brake horse-power compared with the power required for 4 lb. pressure, the increase due to this cause being apparently balanced by a slight reduction in the bearing friction of the compressor.

A further test was made to determine the loss due to piston-ring friction alone, and for this purpose the first and second-stage pistons were removed from the air cylinders. Under these conditions the power taken to drive the compressor, running at a speed of 243 r.p.m., was found to be 9 brake horse-power, this figure representing the frictional losses in the compressor bearings, main guides, and metallic packings, the loss due to the piston rings alone being 21·6 − 9 = 12·6 brake horse-power. It follows from this that about 58 per cent. of the total friction in the compressor is due to the friction of the piston rings on the walls of the air cylinders. The piston rings were examined after the test and the rings were found to be in correct adjustment, showing a good bearing surface without being unduly tight. The cylinders and rings were also found to be well lubricated. It may be mentioned that the oil supply to the air cylinders and piston-rod packings was shut off during the progress of the tests, the final 2 hours' run being without internal lubrication. There was no change in the power taken, the oil fed in during the early part of the test being sufficient to keep the parts well lubricated for a considerable time in the absence of any air draught through the compressor to carry it away.

From the foregoing, the no-load losses may be divided as follows:—

Residual air horse-power	...	...	16·6 b.h.p.
Piston-ring friction	...	...	12·6
Friction in bearings, guides and metallic packings	...	...	9·0
Total	...	...	38·2

Owing to the difficulty already mentioned of calculating the residual air horse-power from the indicator cards, the value given above is that deduced from the power measured at the motor.

When the output of air from a compressor is controlled at the intake by a valve which suddenly and completely opens and closes as required to maintain a constant air pressure, the relation between the cubic foot of air compressed per minute and the brake horse-power will be found to follow the usual straight-line law. The cubic feet of free air compressed per brake horse-power can be calculated for any load from the formula:—

$$\text{Cubic feet per brake horse-power} = \frac{Q \times C}{P \times C + p(1 - C)}$$

Where Q = the full load output in cubic feet of free air per minute, C = the average demand for air expressed as a fraction of full load (*e.g.*, 25 per cent. load C = ¼).

P = brake horse-power input to the compressor at full load.
p = Brake horse-power input to the compressor at no load.

The tests taken on the compressor referred to determine the following values:—

Q = 4,120 cub. ft. per minute.
P = 655 brake horse-power.
p = 38·2 brake horse-power.

The efficiencies of various loads have been calculated from these figures, and the result is shown by Fig. 5. Fig. 1, page 8, is a photograph of the compressor and motor taken on the test-bed during the no-load tests just described.

THE LIBERTY MOTOR.—A description of the Liberty motor has been made public by the United States Department as follows, says *The Iron Age*, New York: Cylinders.—The designers followed the practice used in the German Mercedes, English Rolls-Royce, French Lorraine-Dietrich, and Italian Scotta Fraschini. They are made of steel inner shells surrounded by pressed-steel water jackets. The Packard Motor Company, by long experiment, has developed a method of applying these steel water jackets. The valve cages are drop forgings welded into the cylinder head. The holding-down flange is several inches above the mouth of the cylinder, and a unique method of manufacture has been evolved by the Ford Motor Company. The output is now about 1,700 cylinder forgings per day. Camshaft and valve mechanism above cylinder heads.—The design is based on the Mercedes, but was improved for automatic lubrication without wasting oil, by the Packard Motor Company. Camshaft drive.—This was copied almost entirely from the Hall-Scott Motor Car Company. This type of drive is used by Mercedes, Hispano-Suiza and others. Angle between cylinders.—The included angle between the cylinders is 45 deg.; in all other existing 12 cylinders it is 60 deg. It was adopted to bring each row of cylinders nearer the vertical and closer together, thus to save wind and head resistance and to secure added strength to the crank-case and to reduce vibration. Electric generator and ignition.—A Delco ignition system is used, specially designed to save weight. Pistons.—These are of Hall-Scott design. Connecting rods.—Forked or straddle-type connecting rods, first used on the French de Dion car and on the Cadillac motor car in America, are used. Crankshaft.—The standard 12-cylinder practice is followed, except as to oiling. Lubrication.—Oil under pressure is fed to the main bearings and through holes inside of crank cheeks to crank pins. The oil is thus carried to the crank pins through a hole inside the crank cheek instead of up the outside face of the crank cheek. Propeller hub.—The Hall-Scott design was adapted. Water pump.—The Packard type of water pump was adapted. Carburettor.—This was developed by the Zenith Company. Bore and stroke.—These are 5-in. and 7-in., the same as the Hall-Scott A 5 and A 7 engines, and as the Hall-Scott 12-cylinder engine. Work was concentrated on the 12-cylinder engine, and one of the experimental engines passed the 50-hour test on August 25, 1917.

GOODS LOCOMOTIVE FOR THE VICTORIAN RAILWAYS.

ON page 12 of the present issue we give three views of a locomotive of the "Consolidation" type, which has recently been adopted for working heavy goods traffic on the Victorian Government Railways, which are of 5-ft. 3-in. gauge. The Railway Commissioners of Victoria have long recognised that, in consequence of the steadily-increasing goods traffic, substantial advantages would accrue from the employment of more powerful locomotives than those hitherto in use, but the introduction of such engines was delayed in consequence of the weakness of certain bridges and other structures on the main lines to be traversed. Gradually, however, the structures referred to have been strengthened or renewed, and in 1915 the Commissioners authorised Mr. W. M. Shannon, the Chief Mechanical Engineer of the Victorian Railways, to prepare designs for a locomotive of the Consolidation type, having axle loads not exceeding 18 tons. The result is the locomotive we now illustrate, which has been recently built at the Government Railway workshops at Newport.

The diagram, Fig. 1, annexed, gives many of the chief dimensions, and these we may supplement by the following particulars:—

	Ft.	in.
Diameter of cylinders	1	10
Stroke of pistons	2	4
Diameter of coupled wheels	5	0
Boiler pressure	200 lb. per sq. in.	
Heating surface—	Sq. ft.	
Fire box	173	
Tubes	1,879	
Superheater	369	
Total	2,421	
Grate area	32 sq. ft.	
Tender capacity: Coal... ...	6½ tons.	
" " Water ...	4,600 gals.	
Length of engine and tender over all	64 ft. 4½ in.	
Total weight empty	91 tons 3 cwt.	
" " road worthy ...	127 tons 5 cwt.	

The locomotive, No. 1, C, is of the 2-8-0 type, and it has been specially designed to meet local conditions of working. The boiler is of large proportions, particularly as regards the firebox and grate area to suit the class of coal used on the Victorian railways. The superheater is of the Robinson type, and the chimney, which had to be kept low to clear bridges, is carried down inside the smoke-box, and is bell-mouthed at the lower end. The smoke-box is cleared of ashes by an ash ejector which is worked by the driver turning on a jet of hot water, which flushes out the ash chute, and thoroughly empties the smoke box. Another convenient fitting is that the ashpan door slides can be operated by compressed air by means of a cylinder provided for the purpose.

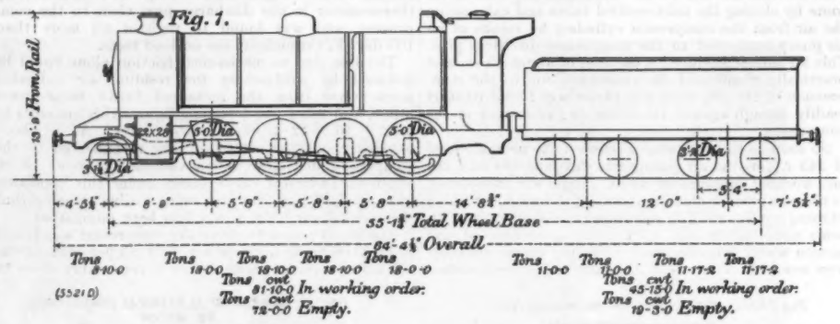
As will be seen from the photograph reproduced on page 12, the valve gear is of the Walscheart type, and is of very compact design. The engine is fitted with a Flaman speed recorder, a Detroit 5-feed lubricator, reflex gauge glasses, and with the Victorian Railways standard injectors, made at the Newport works. All the steel and iron castings, including wheel centres and cylinders, are of Australian manufacture, and the magnesia boiler covering is also of Newport make.

In dealing with the Victorian goods traffic, the work done by the "D.D." class light lines mixed and goods traffic locomotive is taken as the standard, and rated at 100 per cent. It has a tractive power of about 20,000 lb., and its load behind the tender, taken up a 1 in 50 gradient, is 270 tons. Engines of the "A.2" class having a tractive power of about 25,500 lb., are rated at 130 per cent., and will haul a load of 350 tons up a similar gradient. The new type of engine, which we are now describing, has a tractive power of 36,138 lb., and has been rated at 205 per cent. It is estimated that it will take a load of 555 tons behind the tender up a 1 in 50 gradient, or haul a load of 1,600 tons on flat or level country, while, on a fairly level track, such as that between Newport and Geelong, its load is estimated at 1,350 tons.

THE LATE MR. PETER DRUMMOND.—We regret to have to announce the death, which occurred at Belmont, Kilmarnock, on June 30, of Mr. Peter Drummond, who, since 1912, was locomotive, carriage and wagon superintendent of the Glasgow and South-Western Railway. After serving his apprenticeship with Messrs. Forrest and Moor, engineers, Glasgow, Mr. Drummond joined the locomotive department of the London, Brighton and South Coast Railway, where he remained from 1870 to 1875. He then entered the Cowlairs Locomotive Works of the North British Railway. In 1882, he entered the Caledonian Railway, and later became assistant locomotive engineer and works manager, St. Rollox Works, Glasgow. In 1896, Mr. Drummond was appointed locomotive engineer to the Highland Railway, a position which he held until his appointment on the Glasgow and South Western Railway. He was a member, since 1898, of the Institution of Mechanical Engineers.

GOODS LOCOMOTIVE FOR THE VICTORIAN RAILWAYS.

Fig. 1.



NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scotch Steel Trade.—As the holiday season approaches nearer daily, the activity in the steelmaking establishments in the West of Scotland becomes still more marked, the workers putting forth every endeavour to meet the necessary requirements demanded by Government contracts. In this way, arrears are being steadily overtaken, and output considerably increased. If nothing untoward happens within the next fortnight, the way should be clear for the majority of those engaged on this most important work to enjoy a few days much needed rest. Steel plates and sectional material for the shipyards, as well as for new and repair work for the Admiralty, continue to form a very heavy percentage of the output, and, with improved conditions of production, it has been found possible further to speed-up deliveries—a satisfactory result, the effects of which are very considerable.

Malleable Iron Trade.—In the malleable iron trade work goes on apace, the output in both the iron and the steel departments being exceptionally heavy, the bulk of this of course, being required on Government account. Plants are, therefore, being run to their fullest extent, and no effort left untried which will help to increase output and decrease accumulated arrears. Meantime, the larger sections are more in demand than the smaller, various explanations being given for this.

Scotch Pig-iron Trade.—As time goes on, there seems to be an ever-increasing demand for pig-iron of all grades, particularly for work of national importance, and it is indicative of the strenuous conditions under which work is being carried on that there is a constant and heavy pressure for delivery. While all the brands available are in demand, hematite for the steel works still tops the list. There is a growing scarcity of foundry iron, the entire production is swallowed up by the iron works. Consequent on the demands of our own and the Allied Governments, little or nothing is possible for export.

Shipbuilding and Labour.—In the very interesting report which he has just prepared and submitted to the Ship Constructors' and Shipwrights' Association, the general secretary, Mr. Alex. Wilkie, M.P., directs particular attention to the necessity of retaining in the shipyards the services of every skilled and specially-trained man, and at the same time the desirability of constantly adding to this number as occasion occurs in order that efficiency in the construction of merchant shipping may not only be maintained, but very considerably increased. This constructive, or re-constructive, problem is one which employers have to face seriously, although at the moment, perhaps, few but they themselves can quite realise all that it entails. Lord Pirrie is one of the few, and his helpful suggestions should pave the way to a satisfactory solution of the many difficulties.

LONG DURABILITY OF SHEFFIELD STEEL SPRINGS.—Messrs. Cammell Laird, of Sheffield, have recently had returned to them as a matter of special interest a railway wagon bearing spring, as a sample of a number made by the company as far back as 1894, and although these springs have been in constant use, they are still as effective as when new, and are still retained in commission. On testing this sample spring at their Grimesthorpe Works, it was found to be standing at precisely the original camber, and had not taken the slightest permanent set in the 24 years' service. It was scragged home several times, and again came back to the same camber as when first supplied.

EMPLOYMENT ON T.N.T. WORK.—The attention of the Minister of Munitions has been drawn to the great reduction that has recently occurred in the number of cases of poisoning among T.N.T. workers. In the six months from October to March, 1916–17, there were 169 cases of serious illness, whereas in the corresponding six months of 1917-18, there were 42 cases, in April of this year, four cases, and in May, only one case. This result is due largely to a close medical supervision of the workers, combined with improved methods of working, and the substitution of mechanical processes wherever possible. The Minister, therefore, has decided that the factory medical officers, acting within their power under Rule 8 of the T.N.T. Regulations, may permit continuous employment of persons upon T.N.T. work. The effect of this will be a halving of the number of workers coming into actual contact with this explosive.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Labour Conditions.—During the past week, the calls for men for military service, which have been made on the ranks of labour, have had a considerable effect on activities. The "clean cut" of all men up to 23 years of age, has necessarily meant the departure of a great number of employees from local industry, and there is more than a little fear that if recruiting measures encroach much further upon industrial life, handicaps, which, in certain circumstances, might prove very awkward, will undoubtedly be occasioned. In many cases these younger men are "pivot" workers, and their withdrawal from the workshop naturally means temporary disorganisation. Practically every branch of trade has been affected.

Iron and Steel.—In a way, it is fortunate that there has been no acceleration in the demands upon the iron and steel trades. Had this been the case, the works would have been found to be ill-prepared to respond, because the working conditions have been somewhat interfered with, in consequence of the operation of recruiting arrangements. So far as the actual calls for materials are concerned, there is no change to report from last week. Some departments are fairly busily occupied, while others are finding the position decidedly easy. Nowhere are the demands of the situation beyond the producing capacity of the different trade sections. There is a marked boom in the manufacture of farming tools and implements.

South Yorkshire Coal.—The outlook remains as difficult as ever. The general demand is much in excess of the supply, and transactions are being rigidly confined to contract business. Best steams are in strong request among all classes of home consumers, and there is a considerable quantity going away for export. Cobbles, nuts and slacks are being wholly swallowed up by contractors. The demand for household coal shows no slackening tendency. The output still fails by a wide margin to keep up with the arrival of orders, and there is, consequently, a big accumulation of arrears. Nominal prices at the pits are as follow:—Best branch handpicked, 23*s.* to 24*s.*; Barnsley best Silkstone, 23*s.* to 23*s.* 6*d.*; Derbyshire best brights, 21*s.* to 22*s.*; Derbyshire house coal, 18*s.* 6*d.* to 19*s.* 6*d.*; small nuts, 17*s.* 6*d.* to 18*s.* 6*d.*; Yorkshire hards, 18*s.* 6*d.* to 19*s.* 6*d.*; Derbyshire hards, 17*s.* 6*d.* to 18*s.* 9*d.*; best slacks, 14*s.* to 14*s.* 6*d.*; seconds, 13*s.* to 13*s.* 6*d.*; smalls, 9*s.* to 10*s.*

TECHNICAL JOURNALS FOR ENGINEERS OVERSEAS.—In France alone, during the months of February, March, April and May of this year, 1,100 copies of technical papers were sent to the French base, these being made up into sixty parcels, averaging 18 papers each, and forwarded to 21 different depots of the A.S.C. and M.T. These figures refer to the French base only, and similar parcels have been sent each week to Salonica, Mesopotamia and Egypt. Those who still have back numbers of newspapers dealing with the engineering or motor industry, or who are accumulating such papers, are requested to forward them carriage paid addressed to the Business Manager, *Motor Traction*, 20 Tudor-street, E.C.4. Such parcels will be gladly received in order to maintain regular supplies each week to the various bases.

AIR INVENTIONS COMMITTEE.—The Air Ministry state that on April 1 the Air Inventions Committee became a part of this Ministry, and now carries out its duties under the general direction of the Air Council, and in co-ordination with the Advisory Committee for Aeronautics presided over by Lord Rayleigh. The Committee as now organized under the Chairmanship of Sir Horace Darwin, K.B.E., consists of a small permanent establishment and an advisory body of men eminent in aeronautical science and engineering, amongst whom are Sir Richard Glazebrook, Sir Dugald Clerk, Mr. F. W. Lanchester, Professor Petavel, Professor Callendar and Professor Lees, together with a certain number of representatives of the Air Services and of the Technical Departments of the Air Ministry. The Offices of the Committee are 2, Clement's Inn, Strand, W.C. 2, and the Committee will be glad to receive any inventions and suggestions relating to the Air Services, excepting those connected with Airships which should be addressed to the Admiralty. Since the Committee was formed about nine months ago, upwards of 5,000 inventions and suggestions have been examined.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—After last month's very heavy deliveries of Cleveland pig-iron, there is a not unexpected slackening to some extent in demand, to which the approaching holidays in Scotland also contribute in no small measure. All the make, however, is passing fairly promptly into consumption. Foreign trade also shows improvement, and shipments to the Allies are expanding. So far as home business is concerned, July allocations for foundry pig-iron are coming forward only slowly, but they are being issued on a scale that meets the situation. Forge iron is fairly plentiful, both makers and consumers having some stock of this quality. For home consumption, No. 3 Cleveland pig, No. 4 foundry, and No. 4 forge, all stand at 95*s.*; and No. 1 is 99*s.*; and for shipment to France and to Italy, No. 3 and the lower qualities are 114*s.*; and No. 1 is 119*s.*

Hematite Iron.—There is heavy demand for East Coast hematite iron, both on home and foreign account, but careful distribution enables all the essential needs of both home consumers and our Allies to be met, though in many cases deliveries are of a hand-to-mouth kind. Improved truck supply has relieved the position greatly, and the large and still growing use of basic iron and scrap for steel-making assists the situation very materially. Mixed numbers of hematite are 122*s.* 6*d.* for home use, and 147*s.* 6*d.* for export to France and Italy.

Manufactured Iron and Steel.—Unceasing activity characterises all branches of the manufactured iron and steel industry. The exceptionally heavy requests of shipbuilders, and engineers, as well as the extensive demands for constructional material, are being satisfactorily dealt with. Further increase of the huge output is promised in the near future. Prices, all round, are strong. The following are among the principle quotations to home customers:—Common iron bars, 13*l.* 17*s.* 6*d.*; best bars, 14*l.* 5*s.*; best best bars, 14*l.* 12*s.* 6*d.*; iron ship plates, 15*l.* 10*s.*; iron ship angles, 13*l.* 17*s.* 6*d.*; steel ship plates, 11*l.* 10*s.*; steel ship angles, 11*l.* 2*s.* 6*d.*; steel boiler plates, 12*l.* 10*s.*; steel hoops, 17*l.* 10*s.*; and heavy sections of steel rails, 10*l.* 17*s.* 6*d.* Export prices are not fixed, but they are approximately 2*l.* to 3*l.* above home quotations.

Shipments of Iron and Steel.—As was anticipated, the output of pig-iron from the port of Middlesbrough during June were the heaviest of any month so far this year, amounting to 44,047 tons, the previous best being 35,851 tons in April. May loadings of pig-iron were returned at 31,599 tons, and clearances for June last year reached 60,638 tons. Of the pig-iron shipped last month, 37,841 tons went to foreign ports, and 6,206 tons went coastwise. Clearances of manufactured iron for June were returned at 3,231 tons, as against 788 tons for the previous month, and loadings of steel at 13,097 tons, as compared with 6,976 tons for May. For the first half of this year, the total shipments of pig-iron, manufactured iron, and steel are returned at 266,570 tons, 194,960 tons being pig-iron, and 71,610 tons manufactured ron and steel.

Coke.—Scarcity of coke continues to cause inconvenience, but the absolute needs of the blast-furnaces are being met. Fair quantities are being despatched to the Allies, but business with neutrals is practically at a standstill. Sellers are very pronounced in their opinion that the situation justifies higher prices, and advances are confidently looked for. As yet, average blast-furnace coke is 33*s.* at the ovens; and low phosphorus quality 35*s.* 6*d.* at the ovens.

TRADING WITH THE ENEMY ACT.—The Controller of the Foreign Trade Department has issued a new Consolidating List (No. 56A) containing the names of over 3,500 persons and firms with whom persons in the United Kingdom are forbidden to trade under the Trading with the Enemy (Statutory List) Proclamation. Copies of the Consolidated List and of all additional lists, may be obtained at a small cost from the Superintendent of Publications, His Majesty's Stationery Office, Imperial House, Kingsway, W.C. The additional lists are also printed as issued in *The London Gazette* and *The Board of Trade Journal*.

EXPORTATION OF MACHINERY: REVISED REGULATIONS AS TO ISSUE OF LICENCES (CANADA).—It is stated in Customs Memorandum, No. 2,198B., dated May 17, that an Order in Council of March 9, prohibits the exportation of machinery (all kinds) to all destinations outside of Canada, except under licence issued at the request of the War Trade Board. The Memorandum states that it is now required that applications be made to the War Trade Board, Ottawa, for approval of individual licences for the export to any destination of the following machinery, viz.:—Machinery and equipment of all kinds for the manufacture or production of munitions of war; other metal-working and woodworking machinery; ships' machinery; ships' auxiliary; shipbuilding; trenching and ditching; marine engines; sounding machines and gear; aeroplane engines. Parts of the above-mentioned machinery are included in the prohibition requiring licence. In respect of all other kinds of machinery when for exports to British or Allied countries, collectors of customs may issue licences without special reference to the War Trade Board, as the Board has signified its approval of such exportation. It is still required, however, that applications be made to the War Trade Board, Ottawa, for approval of individual licences for the export of machinery of every kind to neutral countries.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Local Markets.—The strength of the large coal market has been fully maintained this week. Outputs are very much down, and the influenza epidemic, which has been so rampant in some parts of the coalfield, has had an appreciably detrimental effect. Even the inferior qualities are well absorbed, those not required for shipment easily obtaining markets inland. The best bunkers and washed smalls are also meeting with a good demand, but the inferior descriptions of smalls are relatively weak, but even with these qualities the position is not so easy as last week. Coke is a steady market, and pitwood and iron ore supply conditions are unchanged.

Newport.—The production of Monmouthshire coals has been adversely affected by the abstentions of a large proportion of the workmen, owing to the spread of the influenza epidemic. There has been a consequent extensive disorganisation of arrangements affecting both the export and the inland trades. In some cases, coals intended for inland consumption have been diverted to the docks for shipment. Practically all classes of large coals are scarce, while the position of the inferior smalls is not so unsatisfactory as it was a week ago.

Colliery Examiners' Dispute.—The lower-grade officials who are members of the South Wales Colliery Examiners' Association, who came out on strike last November, are again restive. On Monday, a meeting of the council of the organisation was held at Cardiff, in regard to the wage rate, and subsequently a joint meeting was held with representatives of the coalowners, when the points at issue were discussed. No settlement was arrived at and the examiners have decided to convene a conference on Monday afternoon to consider the situation. The coalowners, in the meantime, have had the matter reported to them, and it is believed that something like a final settlement may now be reached.

Death of Lord Rhondda.—The death of Viscount Rhondda, the Food Controller, to-day, cast a gloom over the coal and shipping exchange, where he had been so dominating a figure for so many years. All business was suspended in the morning, when the members decided to send a message of condolence to Lady Rhondda and the family. How charming a personality he was is evidenced by the fact that the miners' delegates at the annual conference of the South Wales Miners' Federation, also suspended business, and the general secretary (the Right Hon. T. Richards, M.P.) was unanimously instructed to wire a message to the bereaved family, it being added that Lord Rhondda's death meant a national loss.

THE SCHOOP METAL-SPRAY PROCESS.—By increasing the "atomising pressure" in the "pistol" of the Schoop apparatus, metal deposits of very fine grain and high density and strength have recently been obtained according to a note by K. Matzinger, of Hõngh-Zurich in the Anzeiger für Elektroteknik und Maschinenbau, April 28, 1918, the Anzeiger is a supplement to the Vienna journal of the latter name. The pistol is a blow pipe in which the metallic bead, fused by the flame, is torn away and atomised by the current of compressed air. The ordinary working pressure of the air is 3.5 atmospheres, but the pistol operates on the injector principle, and the actual atomising pressure was so far only 1.5 atmospheres. This atomising pressure has recently been raised to 2.5 and 3 atmospheres without increasing the working pressure, with very promising results. A lead pipe 1mm. wall thickness made by the improved process was filled with hydrogen at 5 atmospheric pressure while lying in water; no hydrogen escaped, whilst hydrogen bubbles forced their way through a lead pipe made by the old process. In another experiment plates of sheet-iron were covered with lead, one or two coatings at pressures of 1.5 or of 2.5 atmospheres. The one or two coatings of the old process did not prevent subsequent rusting of iron, but both the one coating and the two coatings of lead deposited at the higher pressure kept the plates free of rust when they were placed in water.

PRIVATE OWNERS OF RAILWAY ROLLING STOCK.—The twenty-seventh annual general meeting of the Association of Private Owners of Railway Rolling Stock was held at the Midland Grand Hotel, London, on Tuesday, the 25th inst., under the presidency of its chairman, Mr. G. C. Locket. The chairman, in moving the adoption of the report and balance sheet for the past year, referred with satisfaction to the strong financial position of the association. The committee had, he stated, during the past year, found it necessary to be in constant touch with the various institutions and Government Departments connected with the building, maintenance in repair, ownership and running of railway wagons, and mentioned the grounds the committee had for thinking that no further proposal for the pooling of privately-owned wagons was likely again to be brought forward at present. He also referred to the patriotic giving up by a large number of private owners of a percentage of their wagons to the Railway Executive Committee, which had facilitated the withdrawal of the demand for a general pooling of such wagons. After discussion of the matters referred to by the chairman, the difficulties, owing to labour shortage and delays in delivering materials, of maintaining wagons in repair, the report and balance sheet were approved and adopted. A suggestion was then made by a member, and favourably received, that members might help each other in these difficult times by supplying information as to each other's wagons observed to be standing idle on any railway, and afterwards a cordial vote of thanks to the chairman for his great services during the past year was carried unanimously.

NOTICES OF MEETINGS.

THE JUNIOR INSTITUTION OF ENGINEERS (NORTH-EASTERN SECTION.—Tuesday, July 9, at 7.15 p.m., at the Mining Institute, Neville Street, Newcastle-on Tyne. Paper on "Raw Hide Gears," by Mr. T. A. Henderson.

THE ROYAL SANITARY INSTITUTE.—Saturday, July 13, at 11 a.m., in the Town Hall, Swindon. Discussion on "Infant Welfare Work and its Difficulties," to be opened by Mr. W. F. J. Whitley, M.D., D.P.H., M.O.H.; and on "Camp Drainage," to be opened by Mr. Beswick, Military Engineer of Larkhill Camp. The chair will be taken by Lieut.-Colonel H. R. Kenwood, C.M.G., M.B., R.A.M.C., Member of the Council.

IRON ORE IN QUEENSLAND.—The Queensland Government geologist has been carrying on investigations that have resulted in the discovery of a large quantity of iron ore about 14 miles from Warwick. Tests show the ore to contain 66 per cent. of iron, which is the same percentage as that smelted at Newcastle. The Government will conduct its first smelting operations at Ipswich, where 50 tons of Biggenden ore will be treated.

THE INSTITUTE OF METALS.—The annual autumn meeting will be held in the afternoon and evening of Wednesday, September 11, in the hall of the Chemical Society, Burlington House, Piccadilly, London, W.1. The following papers are amongst those that are expected to be submitted:—1. "Cold Drawing of Copper and Its Influence on the Properties of the Metal," by W. E. Alkins (Manchester). 2. "Annealing Cold-Rolled Aluminium Sheet by Abbreviated Exposures at Various Temperatures," by R. J. Anderson, B.S., Met.E. (Cleveland, O., U.S.A.). 3. "Moulding Sands for Non-Ferrous Foundry Work," by Professor D. H. Boswell, O.B.E. (Liverpool). 4. "The Hardness of Metals as Determined by the Resistance to Penetration under Impact," by Professor C. A. Edwards, D.Sc. (Manchester). 5. Note on Manganese Bronze Test Bars, by J. E. Hurst (London). 6. Note on the Use of Liquid Fuel in the Foundry, by Captain A. E. Plant (on Active Service). Offers of other papers or notes should be made to the secretary immediately, if intended for the autumn meeting.

BOY ARTIFICERS IN THE ROYAL NAVY.—The London County Council has been authorised by the Admiralty to nominate a number of boys for entry in January, 1919, as boy artificers in the Royal Navy, and the Council is accordingly prepared to consider applications for nominations. (*a*) Candidates must be between the ages of 15 and 16 years on January 1, 1919, i.e., their date of birth must fall either on January 2, 1903 or January 1, 1904, or *between* these dates; (*b*) Candidates must be the sons of British-born parents; (*c*) Candidates must be in good health and of sound constitution, and be free, as far as can be ascertained, from any disease or defect that would unfit them for the duties of an artificer in the Royal Navy. Their hearing must be unimpaired, and they must possess full normal vision as determined by Snellen's tests, each eye being separately examined; (*d*) Candidates must, as a rule, be not less than 5 ft. 1 in. in height, with a chest measurement of at least 31 in.; (*e*) Candidates must have attended a London secondary, central or higher grade elementary school, polytechnic, or technical institute, for at least one year. This requirement may in certain cases be waived if the candidate possesses the necessary educational attainments as a result of attendance at *evening* classes in higher subjects; (*f*) The parents (or guardians) of candidates must, as a rule, reside within the area of the administrative County of London. Further particulars may be obtained on application to the Secretary, Admiralty, Whitehall, S.W. 1. Application forms (T. 2/249) may be obtained from the Education Officer, London County Council Education Offices, Victoria Embankment, W.C., and must be returned not later than September 3, 1918.

MACHINE TOOLS AND WOODWORKING MACHINES.—A circular letter has been addressed by the Ministry of Munitions to all controlled establishments, pointing out that it is an offence under Regulation 30A of the Defence of the Realm Regulations for any person to buy or sell a machine tool or woodworking machine without the permission of the Ministry, even although such tool or machine may be described as "scrap," and stating that, in view of the fact that it has been brought to the notice of the Ministry that in certain cases machines have been bought and sold as "scrap" in contravention of the regulations, those regulations, in future, will be rigidly enforced. The Machine Tool Department, Charing Cross Buildings, Embankment, must be notified of any machine tools or woodworking machines alleged to be "scrap" which a firm may have for disposal, so that inspection can be made on behalf of the Ministry. The firm will be informed as soon as possible after an inspection has been made, whether the machine tools in question have been classified as "scrap" or as "serviceable" machines. If the machine is classified as "scrap," the fact will be notified by the Ferrous Scrap Department, Whitehall-place, S.W.1, and such "scrap" machine may only be disposed of in accordance with the instructions received from that Department. If the machine is classified as a "serviceable" machine, the fact will be notified by the Department of Engineering (Central Clearing House Section), and the machine will, in that event, be placed on the list of second-hand machines available for transfer kept by the Ministry, and notification of its ultimate disposal will be sent by the Machine Tool Department of the Ministry.

GOODS LOCOMOTIVE, CONSOLIDATION TYPE, FOR THE VICTORIAN RAILWAYS.

CONSTRUCTED AT THE GOVERNMENT RAILWAY WORKS, NEWPORT, VICTORIA, FROM THE DESIGNS OF MR. W. M. SHANNON, M.INST.C.E., CHIEF MECHANICAL ENGINEER, VICTORIAN GOVERNMENT RAILWAYS.

(*For Description, see Page* 10.)

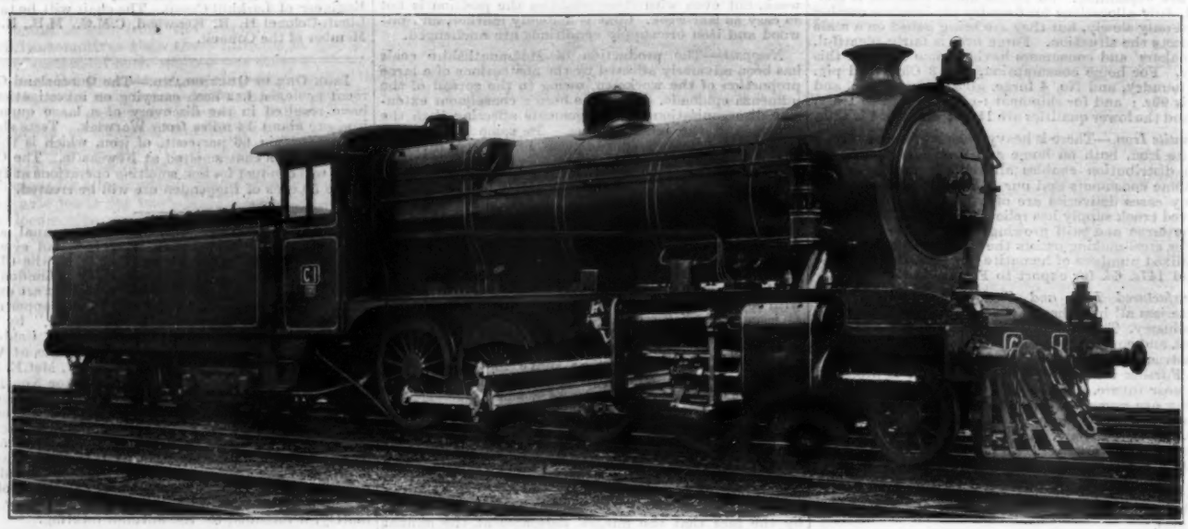


FIG. 2.

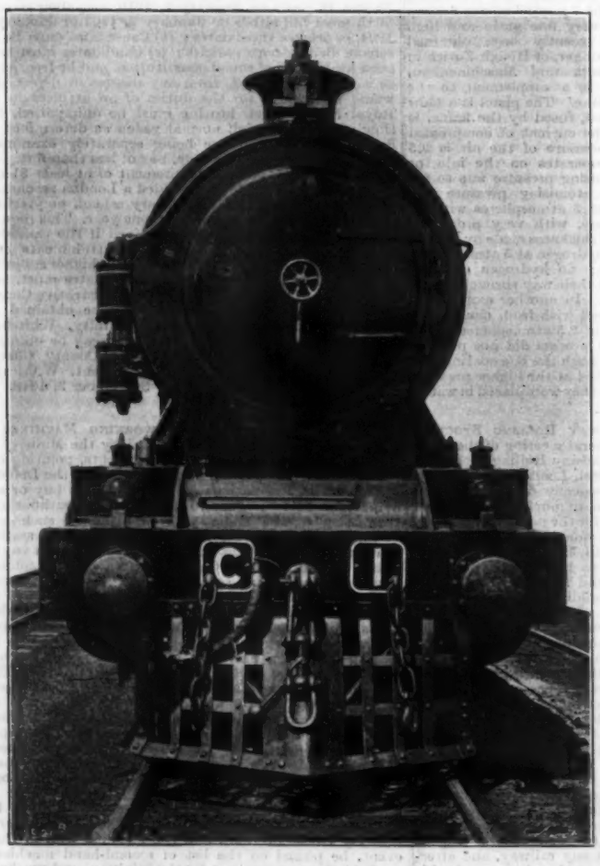


FIG. 3.

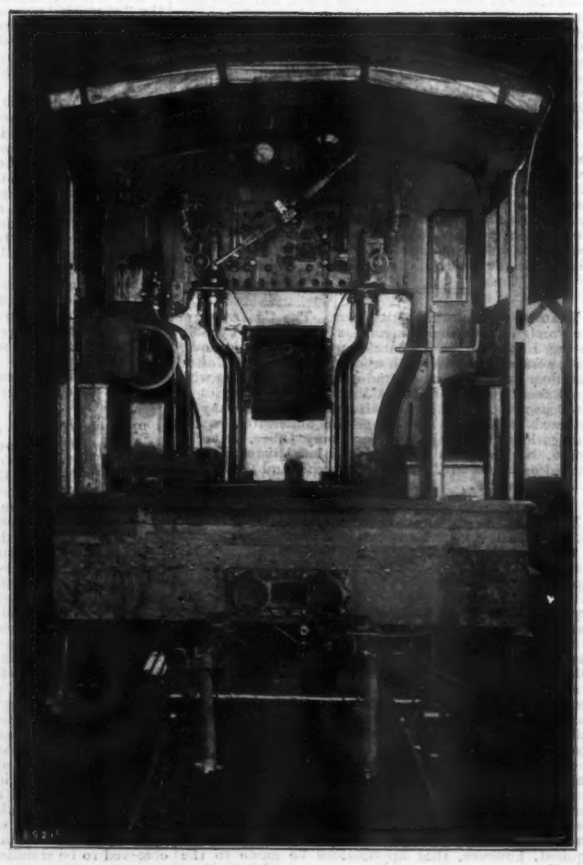


FIG. 4.

THE CUNARD NATIONAL SHELL FACTORY.

(*For Description, see Page* 3.)

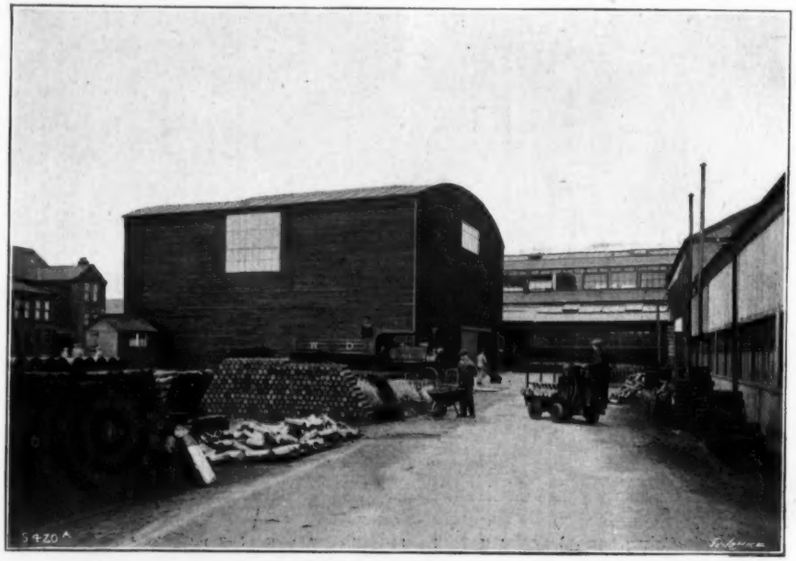


FIG. 1. YARD FOR THE RECEPTION OF RAW MATERIAL.

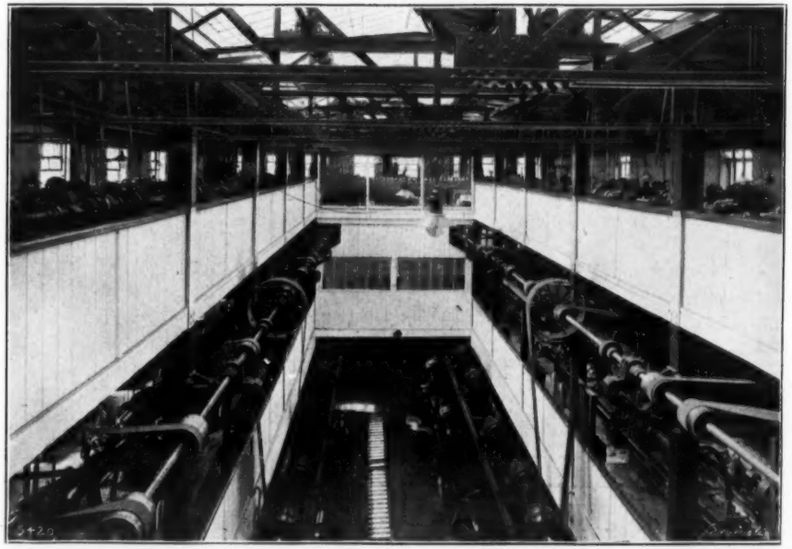


FIG. 2. VIEW OF SHOPS FROM TOP FLOOR, LOOKING WEST.

FIG. 3. TOP FLOOR; NORTH SIDE.

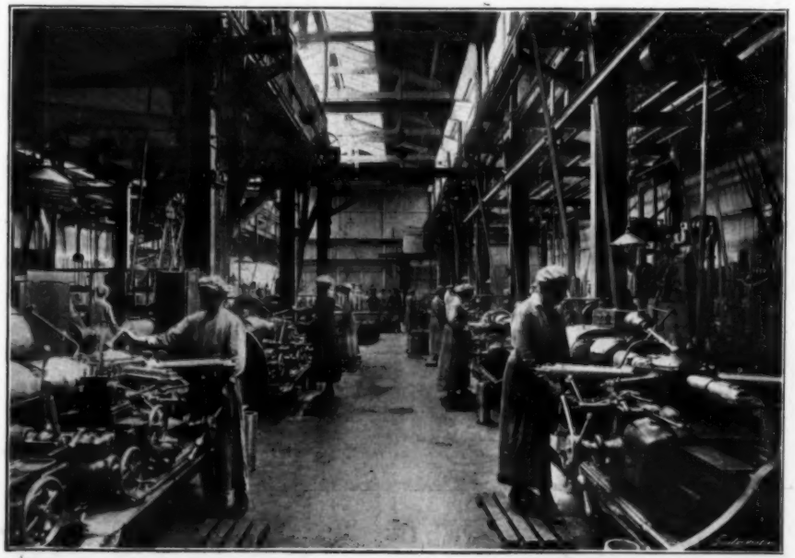


FIG. 4. VIEW ON THE GROUND FLOOR.

(*To face page* 2.)

THE CUNARD NATIONAL SHELL FACTORY.

(*For Description, see Page* 3.)

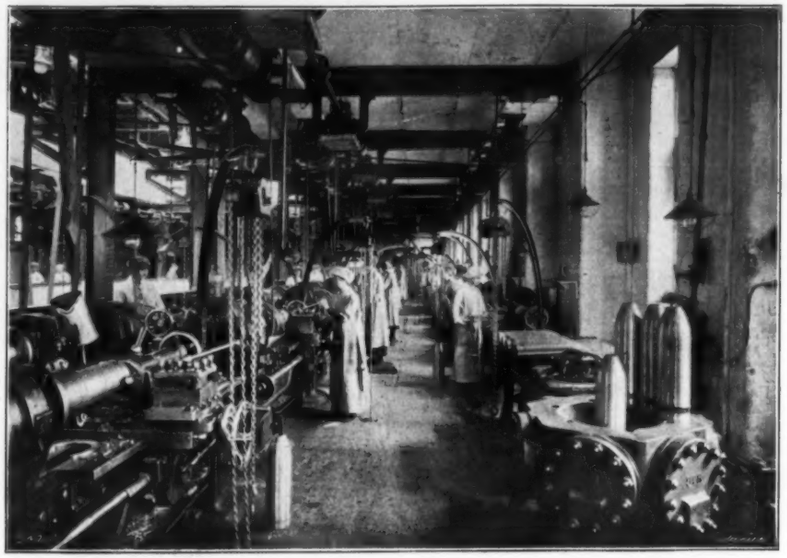


FIG. 5. GENERAL VIEW ON INTERMEDIATE FLOOR (SOUTH SIDE).

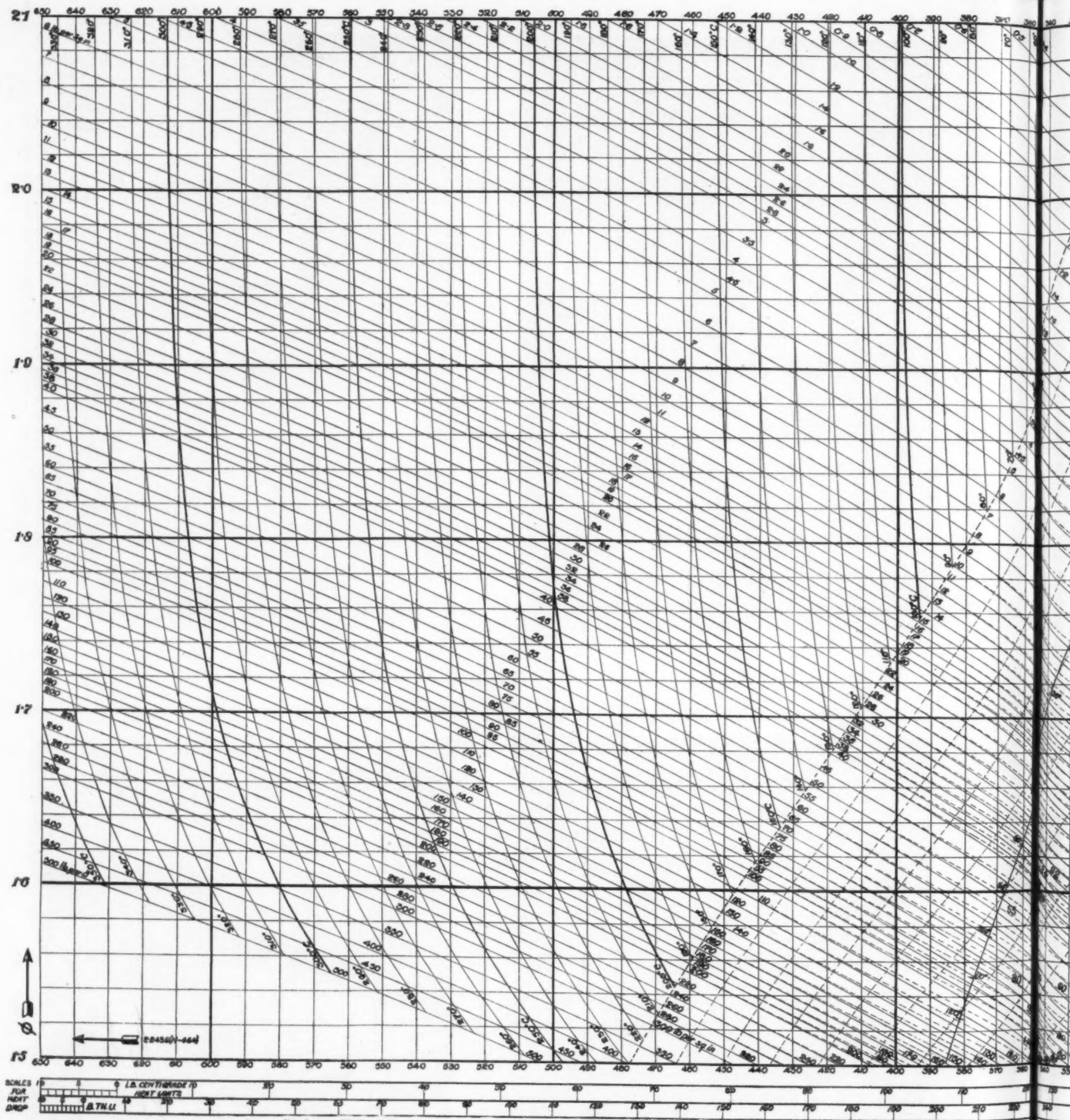
FIG. 6. FINISH-TURNING OF BODY AND PROFILING SHELLS.

FIG. 7. INSPECTION DEPARTMENT, LOOKING EAST.

FIG. 8. FINAL INSPECTION ROOM.

STEAM CHART BASED ON CALL

(For Dear… see Po…



The diagram is based on formulas due to Professor H. L. Callendar, F.R.S., viz.: Let V denote the specific volume in cubic feet of 1 lb. of steam; p the absolute pressure in pounds per square inch; T the absolute temperature in Centigrade degrees; and let H be the total heat of the steam in pound-Centigrade units; then

$$V - 0.01602 = \frac{1.07061\ T}{p} - 0.4213 \left[\frac{373.1}{T}\right]^{\frac{10}{3}} \quad . \quad (1)$$

or

$$V = \frac{2.2436\ (H - 464)}{p} + 0.0123 \quad . \quad . \quad (2)$$

In isentropic expansion of superheated or supersaturated steam.

$$p\ (V - 0.01602)^{1.3} = \text{constant} \ldots (3) \text{ or } p/T^{\frac{13}{3}} = \text{constant} \quad (4)$$

FULL LINES on the diagram refer to superheated or supersaturated steam, DOTTED LINES and heavy figures refer to wet steam in a state of thermal equilibrium. This state of thermal equilibrium is never attained when wet steam expands inside either a turbine or an engine cylinder.

Pressures are absolute, and temperatures in Centigrade degrees. The entropy is constant along horizontal lines, and the total heat is constant along vertical lines. The numbers affixed to these verticals are, however, no… values of H but values of 2·2436 (H − 464).

HEAT DROP.—To find the isentropic heat drop, mark on the diagram the initial state point of the steam, and from this point draw a horizontal to the final pressure line. The length of this line measured on the scale provided is equal to the heat drop. There are two scales, one of which gives the heat drop in British thermal units and the other in pound-Centigrade units.

SPECIFIC VOLUMES.—To find the specific volume of superheated or supersaturated steam, note the value of the abscissa corresponding to this state point. Divide this value by the absolute pressure of the steam and add 0·0123 (see equation 2). To find the specific volume of wet steam in thermal equilibrium multiply the volume at saturation, by the dryness fraction, which is represented on the chart by the dotted curves.

THE WILSON LINE.—Save for the deposit of a thin film of moisture on adjacent surfaces no condensation occurs when the saturation line is crossed during the expansion of steam (J. Aitken, 1880). The steam merely becomes supersaturated and continues in this condition until by further expansion the Wilson line is reached. Up to this limit the law of expansion and the relation between volume, temperature and pressure is exactly the same as for superheated steam. The Wilson line on the diagram has been plotted from the equation: $\log_{10} p - \log_{10} p_s = 3{\cdot}76\ \sigma/T$, where p denotes the pressure of the steam and T its actual temperature; σ is the surface tension of water at this temperature, whilst p_s denotes the saturation pressure at T deg. abso… been extrapolated.

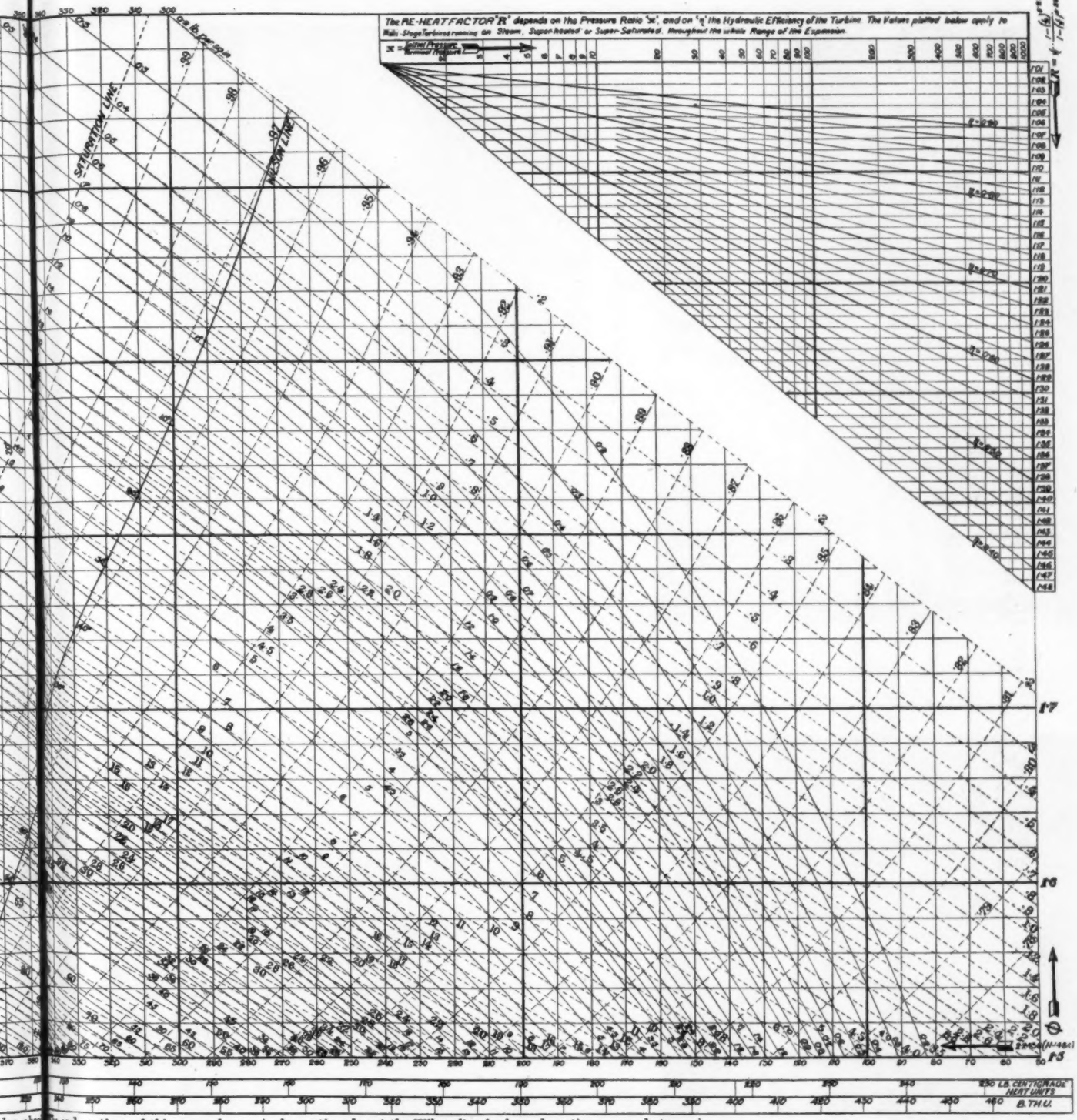
REHEAT FACTOR.—In… dynamic head is not th… multiplied by the rehea… the expansion, and with… less the efficiency the g… done in a multi stage … equal to η R u.

To find the specific vo… in a multi-stage turbo… heat drop u^1, using the … the reheat factor corre… horizontally from the in… to R η u^1 as measured … found, raise a perpendi… to p_2. This intersection… its expansion, accurate… roughly in the contrary… state point is given by …

If the expansion be s… equilibrium is rapidly … can be found by draw… cut the dotted line for …

...LDAR'S TABLES AND FORMULAS.

(... *Page* 1.)


The RE-HEAT FACTOR 'R' depends on the Pressure Ratio 'x', and on 'η' the Hydraulic Efficiency of the Turbine. The Values plotted below apply to Multi-Stage Turbines running on Steam, Superheated or Superheated throughout the whole Range of the Expansion.
SATURATION LINE
WILSON LINE
B.TH.U.

...deg. abso... ...ted.

...CTOR.—In... ...is not th... ...the reheat... ...and with ... ...ncy the gr... ...lti stage ...

...pecific v... ...ge turbine ...using the ...ctor corr... ...om the in... ...easured ... ...perpendic... ...tersection ... accurate... ... contrary ...given by ...sion be s... ...rapidly ...by drawi... ...line for ...

...he end portions of this curve have ...stage turbines the effective thermo-...pic heat drop u, but is equal to u, ...R, which varies with the range of ...raulic efficiency of the turbine. The ...the reheat factor. The useful work ...having an hydraulic efficiency η is ...

...steam after expansion, from p_1 to p_2 ...draulic efficiency η: determine the ...curves of the chart, next take out ...to η and to $x = p_1/p_2$. Set off ...point of the steam a distance equal ...at-drop scale. From the point thus ...ut the (full-line) curve corresponding ...ts the state point of the steam after ...to the left of the Wilson line and ...he volume V^1 corresponding to this ...(2).

...he Wilson line approximate thermal ...nd the final state point of the steam ...cal from the Wilson state point to ...he same pressure. If the expansion be continued past the Wilson line fresh condensation occurs, but on new nuclei. The temperature during this further expansion remains therefore far below the equilibrium value and the specific volume of the steam and the work done by it are much below the values corresponding to the expansion of wet steam in thermal equilibrium.

From the superheat corrections it appears that the specific volume V_w during this stage of the expansion is given approximately by the relation $V_w = 0{\cdot}8\,V^1 + 0{\cdot}2\,V_s$, where V^1 represents the volume calculated as above and V_s the corresponding volume had the expansion beyond the Wilson line been effected in thermal equilibrium. The value of V_s for different hydraulic efficiencies can be found by using reheat factors taken from the dotted lines in the annexed diagram.

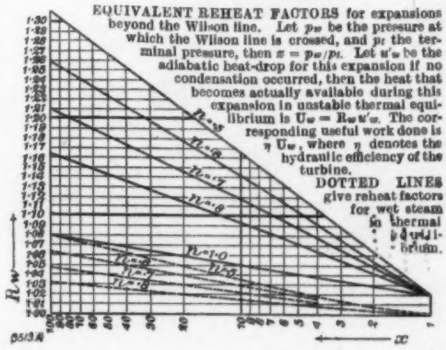
The work done during this part of the expansion can be found by use of the curves of equivalent reheat factors.

Since the steam in expanding beyond the Wilson line is in a "dynamic" condition it is probable that these curves of equivalent reheat factors should be bands rather than lines.

1 kilowatt-hour = 1,895·5 ft.-lb. Centigrade units.
= 3,411·9 British thermal units.

1 horse-power hour = 1414·3 ft.-lb. Centigrade units.
= 2,545·6 British thermal units.

Theoretical velocity of efflux = $300{\cdot}2\sqrt{u}$ (F.P.C.).
= $223{\cdot}8\sqrt{u}$ (B.Th.U.).



EQUIVALENT REHEAT FACTORS for expansions beyond the Wilson line. Let p_w be the pressure at which the Wilson line is crossed, and p_2 the terminal pressure, then $x = p_w/p_2$. Let u'_w be the adiabatic heat-drop for this expansion if no condensation occurred, then the heat that becomes actually available during this expansion in unstable thermal equilibrium is $U_w = R_w u'_w$. The corresponding useful work done is $\eta\, U_w$, where η denotes the hydraulic efficiency of the turbine.

DOTTED LINES give reheat factors for wet steam in thermal ... equilibrium.

THE CUNARD NATIONAL SHELL FACTORY.

(*For Description, see Page* 3.)

FIG. 9. PAINT ROOM.

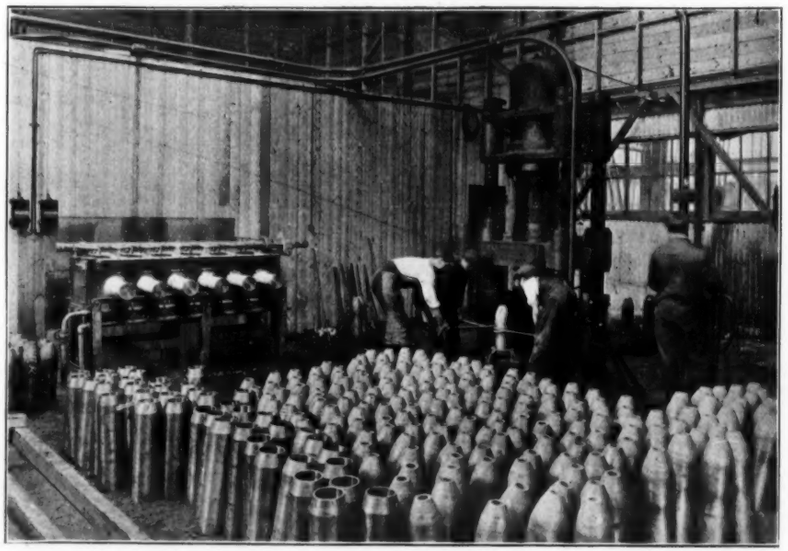


FIG. 10. SHELLS IN FURNACE AND PRESS.

FIG. 11. GENERAL VIEW OF 8-IN. SHELL DEPARTMENT.

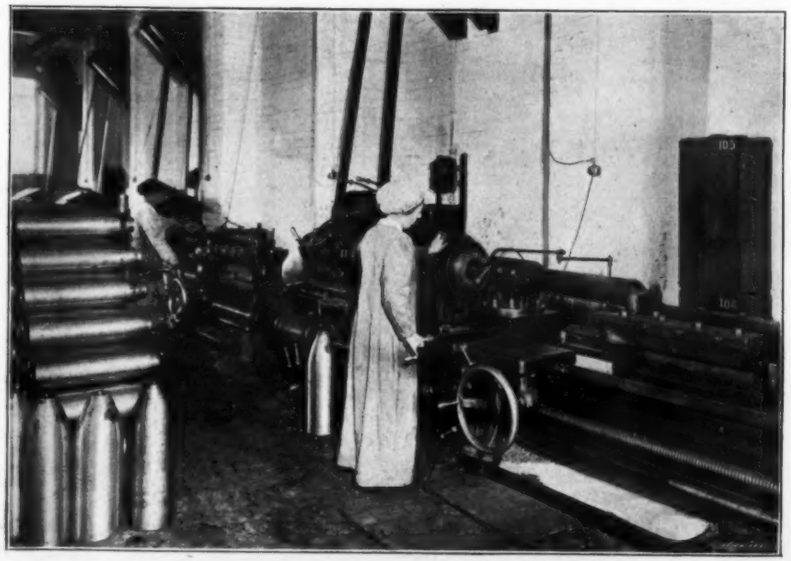


FIG. 12. ROUGH AND FINISH-BORING OF LARGE SHELLS.

THE CUNARD NATIONAL SHELL FACTORY.

(*For Description, see Page* 3.)

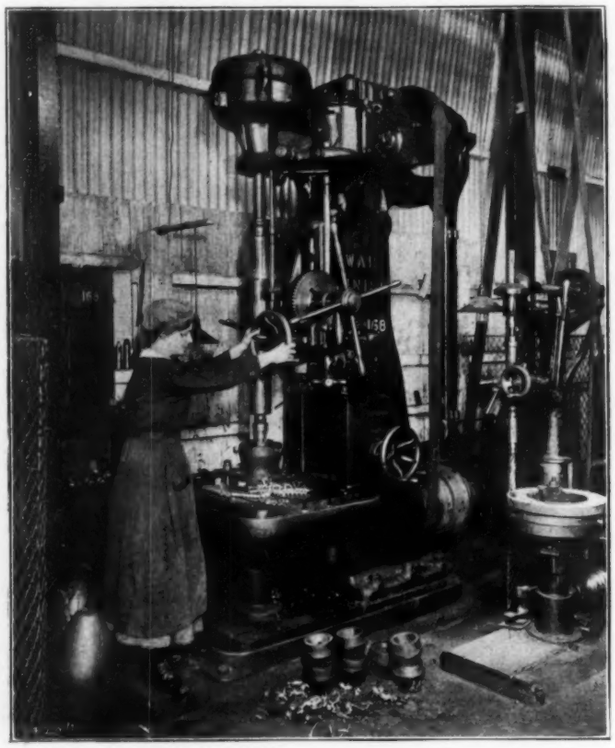


FIG. 13. DRILLING AND CUPPING NOSES OF SHELLS.

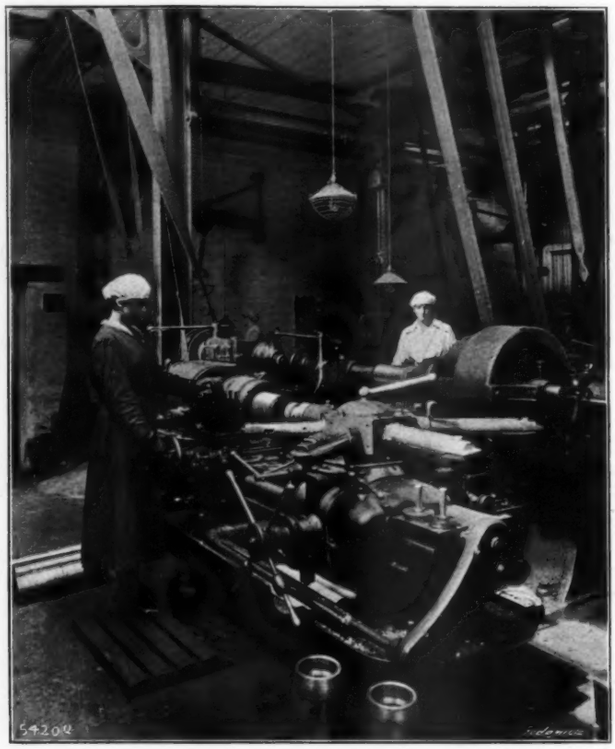


FIG. 14. ROUGH AND FINISH-BORING IN COMBINATION LATHE.

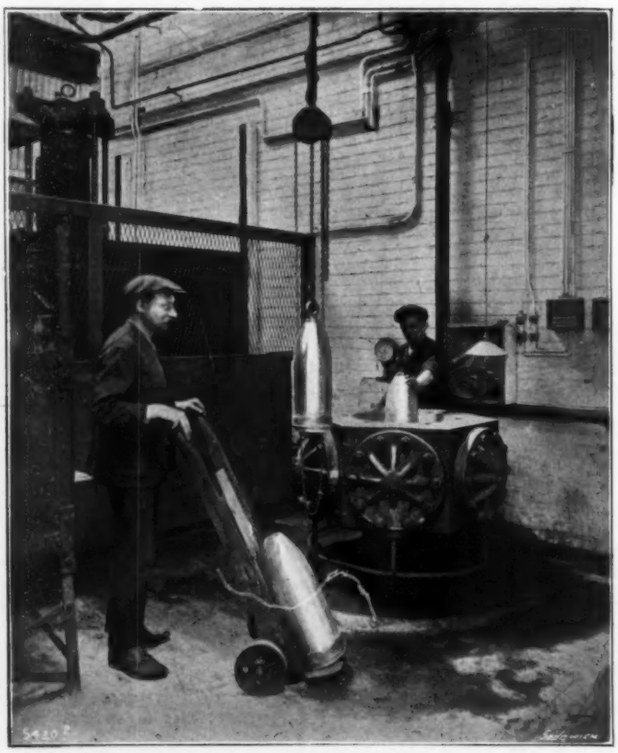


FIG. 15. PRESSING COPPER BAND ON SHELL.

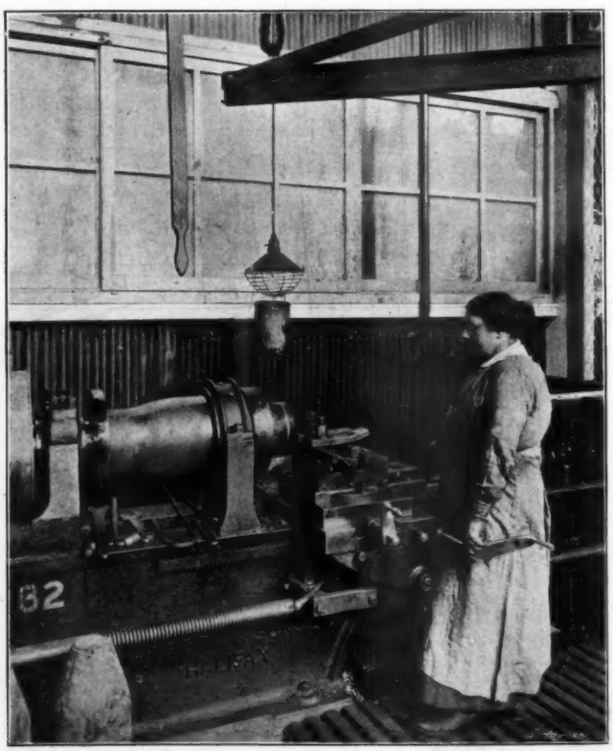


FIG. 16. PARTING SHELL TO ROUGH LENGTH.

(*To face page* 3.)

AGENTS FOR "ENGINEERING."

AUSTRALIA: Gordon and Gotch, Limited, Melbourne; Sydney; Brisbane; Perth. Turner and Henderson, Sydney, N.S.W. T. Willmett and Co., Townsville, North Queensland. W. C. Rigby, Adelaide, South Australia. Melville and Mullen, Melbourne, Victoria.
CANADA, Toronto, Ont.: Wm. Dawson and Sons, Manning Chambers. Montreal: Sells, Limited, 302, Shaughnessy Building, McGill-street.
EDINBURGH: John Menzies and Co., 12, Hanover-street.
FRANCE, Paris: Boyveau and Chevillet, 22, Rue de la Banque. For Advertisements, Agence Havas, 8, Place de la Bourse.
GLASGOW: William Love.
INDIA, Calcutta: Thacker, Spink and Co. Bombay: Thacker and Co., Limited.
ITALY: U. Hoepli, Milan, and any post-office.
LIVERPOOL: Mrs. Taylor, Landing Stages.
MANCHESTER: John Heywood, 143, Deansgate.
NEW ZEALAND: Gordon and Gotch Proprietary, Limited, Wellington, Auckland and Christchurch.
NORWAY, Christiania: Cammermeyer's Boghandel, Carl Johans Gade, 41 and 43.
ROTTERDAM: H. A. Kramer and Son.
SOUTH AFRICA: Central News Agency, Limited, Head Office—Johannesburg; and Pretoria, Cape Town, Port Elizabeth, Bloemfontein, Durban, and their various branches and bookstalls throughout South Africa. Also Cape Town: Wm. Dawson and Sons, 31, Longstreet.
TASMANIA: Gordon and Gotch Proprietary, Limited, Launceston; Hobart.
UNITED STATES: For Subscriptions, New York: W. H. Wiley, 432, Fourth Avenue.
For Advertisements, J. S. Allan, 508, Stratford Avenue, Bridgeport, Conn., U.S.A.

ADVERTISEMENT RATES.

The charge for advertisements is three shillings for the first four lines or under, and eightpence for each additional line. The line averages seven words. Payment must accompany all orders for single advertisements, otherwise their insertion cannot be guaranteed. Terms for displayed advertisements on the wrapper and on the inside pages may be obtained on application. The pages are 12 in. deep and 9 in. wide, divisible into four columns of 2¼ in. in width. Serial advertisements will be inserted with all practicable regularity, but absolute regularity cannot be guaranteed.

Advertisements intended for insertion in the current week's issue must be delivered not later than 5 p.m. on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received not later than Monday morning.

SUBSCRIPTIONS, HOME AND FOREIGN.

REVISED RATES.

"ENGINEERING" may be ordered from any newsagent in town or country and at railway book-stalls, or it can be supplied by the Publisher, post free, at the following rates, for twelve months, payable in advance:—

For the United Kingdom	£2 9 0
For Canada—	
Thin paper copies	£2 5 0
Thick " "	£2 9 6
For all other places abroad—	
Thin paper copies	£2 9 6
Thick " "	£2 14 6

When foreign subscriptions are sent by Post Office Orders, advice should be sent to the Publisher.

Foreign and Colonial subscribers receiving incomplete copies through newsagents are requested to communicate the fact to the Publisher, together with the agent's name and address.

All accounts are payable to "ENGINEERING," LIMITED. Cheques should be crossed "Union of London and Smith's Bank, Limited, Charing Cross Branch." Post-Office Orders should be made payable at Bedford-street, Strand, W.C. 2.

Offices for Publication and Advertisements, 35 and 36, Bedford-street, Strand, London, W.C. 2.

We desire to call the attention of our readers to the fact that the above is our SOLE ADDRESS, and that no connection exists between this Journal and any other publications bearing somewhat similar titles.

TELEGRAPHIC ADDRESS } "ENGINEERING," WESTRAND, LONDON.
TELEPHONE NUMBERS—3863 and 8508 GERRARD.

CONTENTS.

	PAGE
A New Theory of the Steam Turbine (*Illus.*)	1
The Cunard National Shell Factory (*Illus.*)	3
Steam and Power Plant for Chemical Works	6
Industrial Combination	7
"Dumping"	7
Payment by Results	7
4,000 Cubic Feet Air Compressor (*Illus*)	8
Goods Locomotive for the Victorian Railways (*Illus.*)	10
Notes from the North	10
Notes from South Yorkshire	10
Notes from Cleveland and the Northern Counties	11
Notes from the South-West	11
Notices of Meetings	11
The National Shipyards	13
The Health of Munition Workers	14
The late Professor Frederick Remsen Hutton	15
The Admiralty Salvage Section (*Illus.*)	16
Industrial Notes	17
Aluminium Pistons for Aeroplane Engines (*Illus.*)	18
Air Raid Signalling Syrens (*Illus.*)	19
Aeronautical Inventions	19
Trade After the War	20
Diagrams of Three Months' Fluctuations in the Prices of Metals	20
Some Outstanding Problems in Aeronautics	21
Materials Used in the Iron and Steel Trades	23
ENGINEERING Patent Record (*Illus.*)	24

With One Two-Page Plate of a STEAM CHART BASED ON CALLENDAR'S TABLES AND FORMULAS, and Four One-Page Plates of the CUNARD NATIONAL SHELL FACTORY.

NOTICE.

Owing to the recent Government restrictions, and to the enormous increase in the price of paper occasioned thereby, the Proprietors of "ENGINEERING" are compelled to advance the price of this Journal further from 8d. to 9d. per copy. This increase dates from and includes the issue of Friday, March 1, 1918. The change will not apply to unexpired subscriptions. The revised rates for new subscriptions are given in the adjoining column.

NOTICE TO NON-SUBSCRIBERS.

In view of the restrictions now imposed by the Government on the importation of paper and the consequent shortage of supplies, Newsagents after June 24th will not have copies for chance customers, therefore readers who wish to be sure of obtaining "ENGINEERING" each week should place an order for the Journal with a newsagent or bookstall clerk.

NOTICES OF MEETINGS.

Notices of Meetings to take place during the present and next week will be found on page 11.

ENGINEERING.

FRIDAY, JULY 5, 1918.

THE NATIONAL SHIPYARDS.

FEW more serious indictments have been made against public departments than that by the Select Committee of the House of Commons on National Expenditure, in their report relating to national shipyards. Nor can it be said that any of the statements made by the Committee are exaggerations. The gravity of the accusation is increased greatly by the fact that in embarking on a scheme for national shipyards the department concerned did not avail themselves of the technical advice of a Committee which existed for the very purpose of guiding the department in such questions. Moreover, well informed public opinion was averse to the project, and from time to time we have urged the department to relinquish the scheme of national shipyards, as it was not justifiable, either from the point of view of expediency, or of economy in man power and material.

The Committee state briefly the circumstances which led the Admiralty to embark on this "entirely novel scheme" for national shipbuilding yards. The shortage of tonnage for the transport of food supply and raw materials in manufacture, due to the absorption of such a large proportion of merchant tonnage in war service, and, in a lesser degree, to the sinking of ships by enemy submarines and mines, demanded a great acceleration in merchant shipbuilding, and the idea suggested itself to the department that prisoners of war in this country might be utilised in connection with the building of merchant ships, under skilled supervision. As it was not desirable to utilise these enemy prisoners in existing yards, the proposal was made to organise Government establishments. This was the primary reason for the step taken by the Admiralty in requisitioning the yard at Chepstow, which was being organised and equipped by the Standard Shipbuilding Company, and also organising a new yard at Beachley on the River Wye and another at Portbury on the River Avon.

It is well, before offering criticism of the subsequent procedure, to state that the first error in judgment was the assumption that the necessary skilled labour could be secured for the utilisation of the manual power of enemy prisoners. It is only now that we are permitted, through the Report of this Committee of the House of Commons, to disclose the fact that the mysterious references to labour specially available for the national yards, and not for private establishments, was enemy prisoners. At the outset the department ought to have sought advice, even if it be the case that the advice was not given, on the question whether trade unionists would work along with enemy prisoners, even if only to supervise their labour. The view taken at the time by the members of Sir George Carter's Consultative Committee of Shipbuilders, and by the leading trade unionists, was that the trade unions of this country would not assist any Germans to learn any branch of the shipbuilding trade, and this view has since been proved to be correct. Apart from this, all who have had experience during the past few years of the work of prisoners have realised that, even with the strictest discipline, it is impossible to get anything approaching their maximum effort. Consequently the shipbuilding material that was diverted from its normal flow into existing private shipbuilding yards, to enable ships to be built by enemy prisoners in the national shipyards, would not have been utilised to the greatest possible extent. In other words a ship built in a private yard from the material would have been available to meet the nation's need for ocean transport probably in one half the time that would be taken to convert the same material into a ship by enemy labour. As this class of labour is not now available for shipbuilding, Lord Pirrie has very properly decided that the material originally intended for the ships to be built in these national yards will now go to private yards.

The Committee make it clear that the sites chosen at Beachley and Portbury are not satisfactory, and here again one finds justification for criticism of the department in not seeking technical advice, as "owing to the narrowness of the river for launching purposes, the largest class of vessel cannot be constructed." The Chepstow Yard was commenced in 1916 by the Standard Shipbuilding Company, and it was expected that by the end of 1918 eight berths would be available, provided the necessary labour could have been obtained. Events have proved that it would have been better to have encouraged the company by providing, as far as possible, the necessary labour, instead of commandeering the establishment and deciding to run it with enemy-prisoner labour. The difficulties of the site and other conditions have made the undertaking an extremely costly one. No estimates seem to have been prepared and the Treasury were never consulted, two points on which severe strictures are made by the Committee. The scheme was approved in July, 1917, and the sites selected: preliminary operations began in August. In our issue of October 5 we published a severe criticism of the scheme, in view of the appointment then of a subcommittee in connection with the Committee on National Expenditure, but no estimate was accepted until December. On December 21 we again wrote in criticism of the scheme. The cost shown by this estimate was, as we then pointed out, excessive, being at the rate of 120,000*l.* per berth. This, it is true, was to include huts for the prisoners employed on the work. Provision had to be made also for railway sidings, electric power, water mains, &c. But, on the other hand, as the yards were to be used for building "fabricated" ships there was not the same need for moulding lofts, furnaces, bending slabs, or for the punching and drilling of frames, &c. Indeed, the idea was to complete the riveting in the ship of constructed sections as large as could be conveyed by rail. All the preliminary work, involving expensive machinery, was to be undertaken by bridge builders. It was therefore obvious that the expenditure was in excess of that usually incurred in connection with extensions to existing yards, or the institution of new establishments on suitable sites. Fitting-out berths had to be made, and this involved excavation, costing about 500,000*l.*, but this portion of the scheme, on which about 50,000*l.* has been expended, has been abandoned, and the completion of the ships is to be carried out at Portishead. The whole scheme, however, involves the expenditure of about 3,500,000*l.*, and it seems extremely doubtful if any work can be done before the end of the war.

Ten months have elapsed since the inception of the scheme. We are told that only a few of the 34 berths are completed, but that the scheme is well advanced. The hope was that the first ship would be completed by the end of the year, but it has been found impossible to employ military labour for ship construction, for the reason we have already given. If civilian labour is to be employed, housing accommodation must be provided, and if the scheme had been persisted in we should have been in the ridiculous position of depleting existing yards of men and material to convey the latter to an establishment with houses created at great expense,

alike in money, material and man power. Lord Pirrie, however, has come to the wise decision that for the present no ships are to be put together at the national shipyards, the fabricated material going to private works. According to the Committee, the conclusion inevitably arises from this change of policy that no justification remains for taking over the property of the Standard Shipbuilding Company at Chepstow, a conclusion confirmed by the information that it is not intended to proceed with the construction of some of the slips in this yard, on which little or no labour has yet been expended.

Concluding their report, the Committee state that they considered the scheme purely as a war measure, and they add that "since there is no estimate of the cost of a fabricated ship, and no trustworthy conjecture can be made as to the value of the yards after the present emergency has passed, no justification for the scheme on commercial grounds is or can be (in the nature of things) produced. It is evident that the change of policy indicated must result in a postponement of production by the National Yards, and it is doubtful whether the yards will assist to any extent in making good during the war the losses sustained by our mercantile tonnage." As we stated, at the outset, this is a severe, but justified, criticism of a step which would not have been taken if technical advice had been sought. Indeed the department seem to have moved forward contrary to the well founded criticism of authorities, whose advice ought to have been listened to and respected.

THE HEALTH OF MUNITION WORKERS.

THE committee appointed in September, 1915, to inquire into conditions affecting the personal health and physical efficiency of workers in munition factories and workshops has just issued, in a final report, a summary of the whole of the evidence and recommendations, portions of which have been published from time to time as the urgency of special problems demanded or public opinion needed guidance and enlightenment. It is gratifying to know that the views and suggestions put forward have been generally accepted as reasonable, and have been widely adopted both in national and controlled factories, enabling the committee to record their deliberate and unanimous opinion that "there is an increased appreciation of the importance of the whole question of industrial hygiene, and that there can be no doubt that the environment and conditions of employment of munition workers throughout the country are now vastly better than they were two and a half years ago, though there is still much room and much need for improvement." The conditions of health prevailing outside the factory have also engaged the attention of the committee, with the result that the arrangement and equipment of temporary hostels have been much improved, maternity problems have been investigated, and administrative action has been guided along desirable paths. The committee regards its work as an advisory body as complete. The application of agreed principles to particular cases is a problem for the executive, and it is suggested that an Office Committee should be appointed to continue and develop the scientific inquiries that have been initiated, and to carry out an approved policy. Such an arrangement might afford a nucleus for a national scheme of industrial medical research and pave the way for the fuller recognition of the importance of industrial hygiene.

This report is distinctly reassuring and satisfactory, though prejudice and insufficiently informed opinion may cavil at its conclusions, remaining unconvinced in presence of the early errors of the past, and refusing to consider the efforts at amendment. The country at large will, however, give attention and have confidence in the report, for the opinion of the committee is entitled to great weight. Medical science was represented by Sir George Newman, Sir Thomas Barlow, and Sir Walter Fletcher. Pathology and physiology by Professors Boycott and Leonard Hill, and the official element by Messrs. Bellhouse and Collis, of the Home Office. Labour had a representative in Mr. Clynes; manufactuers, in Mr. S. Osborn, of the Clyde Steel Works, Sheffield; while Miss Squire and Mrs. H. J. Tennant, watched the interests of the female operatives. These authorities, though alone responsible for the report, were loyally aided by a long list of able coadjutors, who provided the committee with scientific data and accurate statistics, while the staffs of various laboratories have applied the whole of their experimental resources to the elucidation of many problems.

The report, though originating in an examination of the conditions that make for the health and efficiency of the munition worker, must necessarily take a wider view of industrial interests, and embrace the vital principles and practical methods that affect all forms of manufacture, of which munition working is but one type. Munition factories only rendered more prominent an evil long existent in the body industrial. An industrial revolution was inevitable, and such factories, the product of emergency measures, only revealed in a more startling form, the problems that awakened public consciousness, possibly, public indignation. These may pass away with the circumstances that called them into being, but the question of the health and contentment, the capacity, status and efficiency of the industrial worker, is neither transitory nor superficial. The curative measures, if they are sound and warranted, must be permanent and pervade all schemes for industrial health and betterment. The members of the committee do not profess, and they do not deceive themselves in the belief, that they have solved the problem in its many issues. For this problem in its entirety involves the removal of all occasion of disease and of physical inefficiency, and aims at the husbanding of the mental and bodily resources of the worker in such a way and to such a degree that he can exert his unhampered powers with benefit to himself and the Commonwealth. The student of social science will find here problems of profound usefulness, and the statesman opportunity for the exercise of a firm and bold policy.

The committee points out that in addition to the adoption of measures that secure individual health, mental development, and moral well-being—the fundamental basis of labour and endeavour of all kinds—the social relations between master and man form an important factor that cannot be overlooked. The question of the solidarity of industrial society, the interdependance between employer and workman are referred to, but not discussed, as constituting a political and economic point of view as distinct from that of physical health; and similarly it is laid down as an axiom, that if industry be a national service, the object of those engaged in it is the good of the community as a whole, and the worker is entitled to an effective voice in regard to the conditions under which he works, "and he should have a fair and legitimate share in the responsibility of the transaction."

The committee took evidence and has discussed under 17 heads several branches of the main question, which may be classified under the general subdivisions of the effects and remedies of fatigue; sanitation; personal injuries and industrial diseases; the provision of proper food and clothing; the employment of women; and welfare supervision inside and outside the factory. Of these classes, the influence of continuity of employment or output, or the number of hours of labour and their distribution throughout the working day, has appealed very strongly to the public. Whether this increased attention to a very material point is due to the desire to increase our offensive at the front, or has its roots in a charitable regard for the interests of the worker is not quite clear, but it has opened up a new line of thought and made some conscious that preventive medicine does not consist merely in the isolation of infectious disease, in sanitation and disinfection, or in personal cleanliness, but there is a wider aspect that has its foundations in the phenomena of physiology, sociology and psychology. The science and art of medicine are seen to be not restricted to the diagnosis and cure of disease, but to aim at the maintenance of a healthy, well-nourished and resistent human body. To secure this desirable end the whole man must be dealt with, for he is something more than a machine or an animal. Emotion, intellect, will, in a greater or less measure, determine action, and this is a view of preventive medicine that has been greatly neglected by the profession, and not at all regarded by the public. Fatigue, as an indicator of failing health and capacity, has not received proper attention. The effects of muscular fatigue have been overrated, those of the nervous system disregarded. Medical science, speaking by this report, declares that the tired man refers the symptoms of fatigue to the muscles: "They ache, or they may appear 'to give way under him,' but in reality the most severe bodily activity fails to produce any close approach to complete fatigue of the muscles. The fatigue is fatigue of the nervous system, though in sensation its effects may be referred to the muscles themselves. . . . Even in laborious work it is doubtful whether a man by voluntary effort can cause his muscles to approach advanced fatigue."

Fatigue depends upon the accumulation within the living elements of the products of certain chemical changes. These chemical products have to be removed, and rest after activity is not simply a passive state, but an active process leading to a restoration of the normal capacity for work. Time is required for this process, and the time necessary will be in proportion to the amount of restoration needed. If activity is resumed too quickly, before restoration is completely established, fatigue will become progressively more intense until further action is impossible. The problem for scientific management is to discover the "maximal efficiency rhythms" or alternations of work and repose, best adapted for the various parts and faculties of the human machine. The task of the workman is to accommodate himself to the *règime* imposed in the arrangement of hours, shifts, spells, pauses, the periods of sleep and holiday on the one hand, and the conditions of factory environment on the other. Fatigue should be detected and its causes removed while it is still latent. Its symptoms are evidenced in lowered output, increased number of accidents, spoiled work, staleness, ill-health and lost time. The prevention of its evil effects demands: (1) Intelligent observation of the output; (2) regular study of the returns of sickness and lost time; (3) prompt initiative in adapting the hours and conditions of work to physiological need; and (4) by providing proper facilities for the feeding, resting and recreation of the worker. The committee are of opinion that the recognition of the causes and remedies of fatigue is far from general. "Taking the country as a whole, the committee are bound to record their conviction, that conditions of reduced efficiency and lowered health have often been allowed to arise, which might have been avoided without reduction of output, by attention to the details of daily and weekly rests and other similar means of welfare and favouring conditions."

Closely connected with the origin of fatigue is the number of working hours and their distribution throughout the day and night. This subject early engaged the attention of the committee and a reduction in the working hours was one of the first fruits of their deliberations. It seems strange to read now, that in the early days of the war skilled male workers were employed for as much as 90 hours and occasionally 100 hours a week, while women toiled for 70 hours or more. In January, 1916, it was proposed to reduce the average weekly employment of men to 67 hours, of women and boys to 60 hours, while night work was to be limited as far as possible. The testimony of Dr. Vernon on these ameliorations is conclusive. Using statistics derived from special industries, he shows that a reduction of from 7 hours to 20 hours per week of actual work in no case resulted in more than an insignificant diminution of total output, while on the average, it produced a substantial increase. The committee, now guided by further observation and enlarged experience, recommend the further curtailment of working hours. The members are convinced that with proper regulations, larger reductions might be made with benefit to health and without injury to output. They mention with approval, the Government proposal to try the experiment of 50 hours in some of the national factories, and quote without material comment, Lord Leverhulme's advocacy of the establishment of a 6-hours' day.

With regard to overtime, the evidence does not

appear to be conclusive, though opinion will generally coincide with the advice of one witness, who urged that overtime was not profitable, if paid for at 1¼ rates. The trades union representatives urged, not without reason, that where overtime exceeds 2 hours daily there is evidence of fatigue, and men cannot be employed economically. The committee taking a middle course are not inclined to sanction more than 10 hours to 12 hours overtime a week.

The daily hours of employment will naturally be determined by the weekly. Though night work is open to serious objections, the committee give a guarded approval of the plan of "double shift," with an interval between the two to admit of cleaning and ventilation. The arrangement of "three shifts," where women are continually employed, has much to commend it, though difficulties may arise in accommodating the hours of men and women workers. Work before breakfast is regarded as injudicious and wasteful, but in the "one-break" system, if workpeople are employed for the full spell of 5 hours on continuous work, uneconomical and injurious consequences may follow. Short intervals for refreshment, systematically arranged, are recommended as affording opportunities of recovering from fatigue and making a welcome break in the monotony of work. These considerate recommendations of the committee on behalf of the worker extend to Sunday labour and night work. Public opinion has declared emphatically against the former and the report endorses the general condemnation. Night work, too, is regarded as open to serious objections. To insist on sleep by day is difficult, and the habit is disliked because social intercourse and recreation can hardly be obtained, except by undue curtailment of healthy sleep. Night work for young girls has been stopped, for women it has been disapproved, and as soon as possible the illegality which has been relaxed under war conditions, will be again strictly discountenanced.

The care of women workers presents unusual difficulties; the sudden inrush of female labour, due to patriotic motives, was not foreseen and arrangements were inadequate. Conditions of work have been accepted by applicants without question and without complaint, which, if continued, would be ultimately disastrous to health. It is particularly necessary to protect and safeguard the possible mothers at this crisis in our history, lest irreparable injury should be done to mind and bodily health in this generation and the next. The importance of the office of motherhood compels our attention, and would alone have justified this inquiry and report. More than ever in the past, should consideration be given to the working mother, whose care is especially claimed by her infant during the first months of its life, for her welfare and usefulness are more than ordinarily threatened by conditions of employment.

Equally on the other hand, the committee appreciates the exceptional importance of women's labour in the present emergency, and are most unwilling to suggest the imposition of conditions that would possibly embarrass employers or restrict the valuable contribution female workers so willingly offer. The members confine themselves to the examination and discussion of certain urgent factors in the general control, and record their satisfaction "that the women and girls employed at these factories are as a whole bearing the strain of their munition work remarkably well." This conclusion is not a vague expression of opinion, it is based on two medical inquiries that have been prosecuted with some care, and separated by a considerable interval of time. For obvious reasons these investigations are not so thorough and complete as the authorities would have wished, yet they probably represent the average conditions, and this view is supported by the general agreement found between these independent inquiries as shown by the following figures.

—	Number of Workers Examined.	Number Found in Full Health.	Number Showing Signs of Fatigue.	Number Showing Marked Ill-Health.
		per cent.	per cent.	per cent.
Inquiry No. 1	1,326	763=57.5	451=34.0	112=8.5
Inquiry No. 2	1,183	692=58.5	425=35.8	66=5.7

Up to the present, it is stated in the report that there has been no marked break down in the health of women in industry, but any satisfaction this opinion may afford is qualified by the apprehension that "many women are only able to keep working by a total abandonment of all recreation or social intercourse."

A fear is generally entertained and finds some support from this report, that particularly in the case of women, food is not adequate in amount nor nutritious in quality, is neither fresh, digestible, nor appetising. The difficulties may be aggravated by the distance between the home and the workshop, and the workers' ignorance of proper food values. The only satisfactory remedy in the opinion of the committee lies in the establishment of industrial canteens. In these the convenience of the workers can be consulted, prompt service secured, and an acceptable system of management contrived. At the end of 1917, 840 canteens were operating in munition works and at docks. Though the need for such institutions has been accentuated by the war, they have proved so beneficial they might be regarded as permanent factory adjuncts.

Welfare work, or "physiological management," as some prefer to call that branch of factory management, which studies the worker in relation to his work and the work in relation to the worker, receives much attention from the report. The need for some form of adequate inspection in the conduct of factories was early apparent and the "welfare supervisor" came on the scene, whose duties on the one hand and whose capabilities on the other had to be learned by experience. When possessed of strength of character, tact and broadmindedess, the supervisor has proved a very desirable aid to the management in the investigation "of cases of lost time low output, wages, incapacity, dismissals or withdrawals, working conditions, home visiting, feeding arrangements, training and instruction, housing, transit and recreation." On the whole, it is to be gathered that the supervisors have fulfilled a useful function, but what permanent form such an office will take cannot yet be decided. Unwise appointments have been made, and these have tended to bring welfare supervision into disrepute. Complaints, says the report, have been considerable, and often well founded, though their importance may have been over emphasised. On general grounds, the appointment of a body of instructed persons, possessing the confident support of the workers, and specially devoted to the promotion of their health and well-being, is likely to prove of material advantage to all concerned.

Though undoubtedly the manufacture and manipulation of toxic chemical substances upon the immense scale required in war operations have brought many special dangers to the health and lives of munition workers, it is not necessary to consider here any technical questions that arise in the treatment of special industrial diseases, injuries and accidents. These, unfortunately, are always with us, and having been the subject of much investigation are generally provided for under various Factory and Workshop Acts.

The numerous appendices attached to the report should, however, not be passed over without a slight comment. Some of these have entailed much work on their respective authors, and will repay careful study. Attention should be more particularly given to Dr. Janet Campbell's "Enquiries into the Health of Women Munition Workers," and Dr. Vernon's memorandum "On a Comparison of the Systems employed for dividing up the working hours into Spells and Breaks." The description and plans of hostels and canteens, founded as these plans are on a wide experience, should prove instructive and useful.

THE LATE PROFESSOR FREDERICK REMSEN HUTTON.

WE regret to have to record the death, which occurred suddenly from heart trouble, on May 14, in New York, of Professor Frederick Remsen Hutton, who for twenty-three years was Secretary of the American Society of Mechanical Engineers, then its President for one term, and, later, was elected the Honorary Secretary of the Society.

Professor Hutton was born in New York on May 28, 1853. After preparation in a private school in New York, he entered Columbia College, receiving the degree of A.B. in 1873. After graduation he entered the School of Mines, and was given its degree in 1876. A year later, he was appointed instructor in mechanical engineering as an associate of the late Professor W. P. Trowbridge. It is stated in the *Journal of the American Society of Mechanical Engineers*, to which we are indebted for the information embodied in this memoir, that this was the first recognition which Columbia gave to the important relations of mechanical engineering to other engineering courses. Professor Hutton entered the faculty as adjunct professor in 1881 and became professor in 1890. Upon the death of Professor Trowbridge in 1892, the chair of engineering which he had occupied was divided, and professorships in civil engineering and electrical engineering were added to the already existing professorships of mining and mechanical engineering. Professor Hutton was made the head of the mechanical engineering department, which he directed until July, 1907, when he resigned, and in appreciation of his valued services was elected professor emeritus.

Professor Hutton's history is practically that of the American Society of Mechanical Engineers, which for about three years after its foundation met periodically at the office of Mr. Henry R. Worthington one of the original members. Professor Hutton became Secretary to the Society at a salary of 1,000 dols. per annum in March, 1883, three years after its organisation, when the membership was less than 400. He was then thirty years of age, junior Professor of Mechanical Engineering at Columbia University, and able to arrange to give part of his time to the management of the Society's business whilst fulfilling his duty as teacher. The office of Mr. Henry R. Worthington was given up, and for a period the headquarters of the Society were in Professor Hutton's study in Columbia University. But it was soon found desirable to have an office in town, and the subject of our memoir rented at his own expense a room in what was known as Smith Building, 15, Cortlandt Street; he then engaged an assistant whose salary he also paid. From that time onward, through the wise management and strong personality of the new Secretary, supported by the staunch original members, the Society grew and prospered consistently year by year. In 1890, the house at 12, West Thirty-first Street was purchased for 60,000 dols.; its acquirement was an ambitious project for a society without funds, but the financial difficulties were overcome by a committee, of which Mr. J. F. Holloway, Mr. Stephen W. Baldwin and Professor Hutton were members. The same property was sold in 1906 for 120,000 dols.

The first meeting at which Professor Hutton acted as Secretary was the one held in Cleveland in 1883, where the papers were for the first time distributed in advance in the shape of galley proofs, with the cuts printed on separate sheets. A trip to Europe took place in 1889,* and this had a wide influence in giving international recognition to the Society and establishing a bond of professional fellowship between the United States and the countries visited. Another notable meeting was that at Chicago in 1893, at the time of the Engineering Congress held during the Columbian Exhibition.†

The Society gradually outgrew its quarters, and after sixteen prosperous years moved to the splendid Engineering Societies Building, which it now occupies jointly with other engineering societies.‡ Professor Hutton was a member of the Joint Conference and Building Committee appointed to carry out the generous intention of Mr. Andrew Carnegie to provide the building for the use of the several societies and a building for the Engineers' Club. He was also Secretary of the Building Committee and, later, Secretary of the United Engineering Society. Professor Hutton was, further, one of the Board of Trustees of the last-named Engineering Society.

At the end of twenty-three years' service and coincident with the removal to the new building,

* See ENGINEERING, vol. xlviii, pp. 17, 51, and 113.
† See ENGINEERING, vol. lvi, pp. 245 *et seq.*
‡ See ENGINEERING, vol. lxxxiii, p. 96.

Professor Hutton resigned his position as Secretary; he felt that the moment had come when the Society needed the full time and energies of a secretary who should not be compelled to share these with the engineering department of a University. It seemed proper that he who had led the Society through its successive stages of development should be elected to the presidency, and Professor Hutton was made President for the year 1906-07. In 1908, he was elected Honorary Secretary, a distinction which he held until his death.

In 1911, Professor Hutton served as consulting engineer to the Department of Water, Gas and Electricity, New York City; from 1905 to 1911 he was Vice-Chairman of the Museum of Safety. He was Consulting Engineer to the Automobile Club of America and Chairman of its Technical Committee from 1912. He was one of the first engineers in the United States to use an automobile and to enter into a study of automobile construction. Professor Hutton was also a member of the John Fritz Medal Board of Award. In 1882, Columbia conferred upon him the degree of Ph.D., and, in 1904, the degree of Sc.D., the highest distinction of the University.

Professor Hutton was the author of several books and of several papers presented to the Society. A treatise of his on "Machine Tools," written for the Census of 1880, stood out as one of the important documents of the time and was used by engineering schools for the instruction of their students. He also wrote two text-books—on "Mechanical Engineering of Power Plants" and on the "Gas Engine." He was Editor for encyclopædias and dictionaries, notably the "Century," of 1911. He also wrote the history of the American Society of Mechanical Engineers, which was issued in 1915, forming a handsome illustrated volume.

His loss is mourned by a large circle of friends, as is evidenced by the number of interesting letters which appear in the last issued journal of the Society with which he was so long and so honourably associated.

THE ADMIRALTY SALVAGE SECTION.

IN the course of a short article on page 698 of our last volume we gave a brief account of the work accomplished since the war by the Admiralty Salvage Section. In many of our preceding volumes will also be found illustrated descriptions of the successful salvage operations carried out in pre-war times, and for a number of years past, both in British and foreign waters, by the Liverpool Salvage Association, under the direction of Captain Fred. W. Young, who, together with his staff of officers and men, has since the beginning of the war been employed by the British Government in active salvage operations in connection with the Admiralty Salvage Section. We need not refer here in any detail to our former descriptions of pre-war salvage questions; as will readily be understood, these questions have varied in every separate case and have enabled the Section, largely assisted by the Liverpool Salvage Association nationalised for the time being and increased with regard to means of working, to acquire a vast experience in the difficult problems which are involved in the salving of ships and of their cargoes. This experience, coupled with the enterprise, resourcefulness and bravery of all officers and men in charge, has enabled the section to deal in a most satisfactory manner with the work put under their charge. Since the war began they have displayed great activity and have devised and used many improved methods of carrying out their tasks.

With reference to this Department, the Admiralty have displayed considerable foresight in obtaining the services of trained experts. One of the most extraordinary features of salvage work in general is that although one of the highest branches of engineering it is generally thought to be a profession in which anyone having a knowledge of the sea is capable of carrying out intricate salvage problems without previous experience and technical training. The wisdom of the Admiralty choice is seen in the many successful results that have been achieved, and the successful career of the Chief of Staff is too well known to necessitate any particular reference from us. Personally, he has been associated from the Liverpool Salvage Association since the war commenced, has served with the Grand Fleet, and has been at sea since the beginning until a couple of months ago.

The plant of the Section consists in the main of a large number of outclassed gunboats which have been converted with a view to their use for salvage purposes; they are distributed all round the British coast, and are equipped with wireless telegraphy apparatus and with all the necessary gear such as portable steam pumping sets which can be supplied with steam from the ship's own boilers, or from portable steam boilers which are held in readiness for an emergency at a number of ports. Each boat carries also several portable petrol motor driven pump sets, and electrically driven pump sets, all these various pumps varying from 12-in. down to 6-in., and each set capable of delivering from 250 to 800 tons of water per hour, according to its size. Besides the above, each boat carries also a number of submersible, electrically-driven motor pumps, the 4-in. pattern being able to deliver 100 tons per hour at a 75-ft. lift. The complete pump equipment of one boat is capable of dealing, when working at its full capacity, with a total of 10,000 to 13,000 tons per hour. The electrically driven pump sets are supplied with current from the electric generators in the boat's engine room. It is only in extreme cases that outside aid in the shape of additional steam or additional current is called for. In the

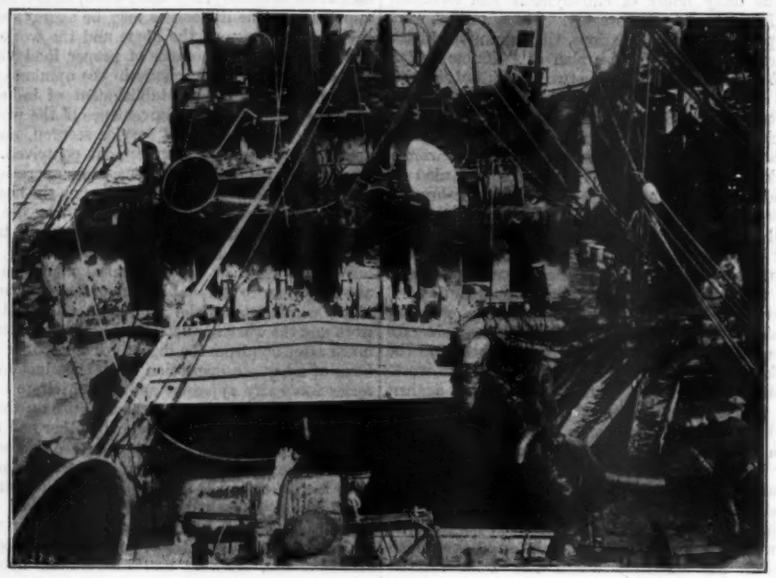


FIG. 1.

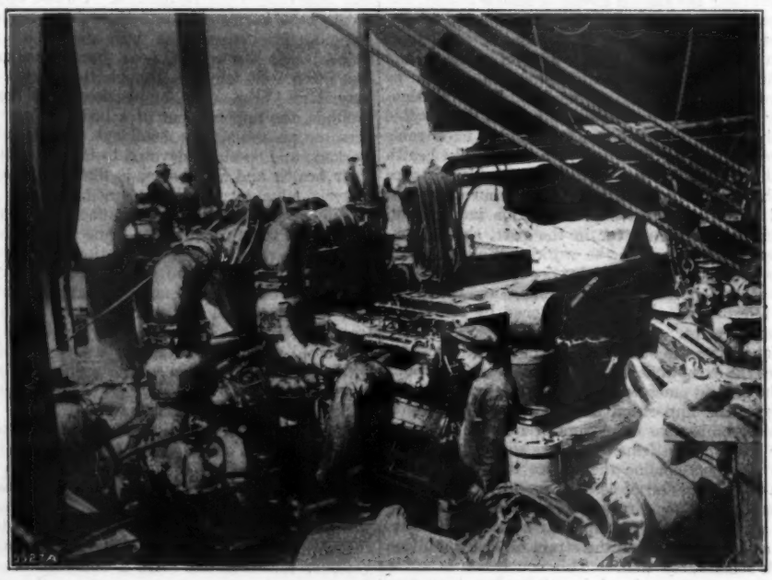


FIG. 2.

sides of the salvage boats, on deck, are carried chests containing all the gear and piping for connecting up the wreck with the salvage boats. These latter are also equipped with line-firing guns, and with gas bottles and implements for cutting by oxy-acetylene blowpipes.

We had the opportunity of witnessing last week in one of our ports salvage operations in course of progress in charge of the personnel of the Section and of visiting several of the salvage boats dealing with these operations. One of the boats, we may mention, has been able to salve eight ships since

May 10, a most gratifying performance. On this occasion we were shown, among other ships, an oil tank steamer and a general cargo steamer. The former is salved, whilst salvage work is still in progress on the latter. Both ships were inward bound a few weeks ago and collided together at night time in British waters in the act of getting out of the way of an outward bound steamer. The principal part of the cargo of the oil tank steamer consisted of 20,000 tons of naphtha; she was equipped with pumps and gear of a capacity sufficient to discharge herself in 24 hours—this affords an idea of her size. She caught fire immediately the collision occurred and sank, going down by the stern. She was immediately taken in hand by the Section, who patched her up, pumped her out and towed her into port; at the present time she is in dry dock, rendered seaworthy so as to enable her, at the request of her owners, to reach her home port, under her own steam, for complete repairs. Her decks, bulkheads and all her upper works have been completely distorted under the intense heat developed by the burning oil. Her engines and boilers, which are right aft, fortunately suffered very much less from the fire, as the engine and boiler holds were flooded comparatively early after the collision, and whilst they were being pumped out in the course of the salvage operations care was taken to clean them and put them gradually in working order afresh, as the depth of the water in the holds gradually decreased.

The general cargo steamer with which she collided also carried mineral oil; she was set on fire immediately after colliding and burned intensely. Shots were fired into her to sink her and thus to put out the flames. She is now being salved. A salvage boat is in constant attendance alongside her; at the time of our call last week the salvage boat was pumping water out of her aft hold at low tide, and the boat's derricks were unloading from the same hold, with the help of divers, the miscellaneous heavy cases and packages it contains, covered by sea water and by a noisome, semi-liquid, greasy black mixture of all the various residues of combustion. At the same time also ships' carpenters from the same salvage boat were shoring up the deck and bulkheads, and divers were exploring on the outside the holes in the hull and carrying out the preliminary work for the manufacture and putting in place of the patches. While all these operations were in progress, the wreck from the aft end was constantly under the action of a tug which drew it foot by foot, as the lightening operations progressed, closer to the beach, into comparatively shallow water, so as to facilitate further operations. For the present, at the site where the wreck now lies, all work has to cease during high tide, at which period the deck of the wreck is totally under water. At the rate at which operations are now proceeding, it is expected that the wreck can be moved very shortly into shallow water, when the patching up and the exhausting of the various compartments will proceed apace. We illustrate in Figs. 1 and 2 on the opposite page a view of the aft hold of the cargo steamer, and a view of the deck of the salvage boat alongside, showing petrol driven pumps in operation.

In former salvage operations, when no caissons, pontoons, or other similar means of floating a wreck were used, resort was had to patching up the hole caused in a ship's side by collision or by the ship striking a rock; after cutting away all rugged outside projections of ship's plates and sections, a canvas bolster, stuffed with oakum, was placed over the sound plating round the hole, and the latter was planked on the outside longitudinally to the ship, the divers commencing at the lower part of the site, drilling the necessary holes under water, and fitting in position a succession of timbers, the thickness and length of which varied with the surface to be covered, the width of the timbers being generally 12 in. The timbers were secured by bolts having at their inner end, therefore inside the ship, a hook which was attached to any available point, and at the outer end a threaded portion to take a butterfly nut. By this means, each successive timber was secured in place by divers working inside and outside the ship. The timber seams were next covered by canvas overlaid by battens. In some instances and at the turn of the bilge, the hole might be planked in a similar way by means of separate planks placed one by one, side by side, but transversely to the ship's axis. The ship was then pumped out.

The present method of stopping up a hole temporarily in a ship's side previous to pumping out, whether the hole be caused by ordinary marine risk, or by a mine or a torpedo, namely, by the use of the "standard patch," is a quicker method and a more satisfactory one in every way. When the divers have ascertained and reported upon the location and the size of the hole, they take down a timber mould which has been prepared on the basis of the lines of the ship and having the con'our of the damaged portion on the outside; they see if it fits or mark where adjustment is required, and from the investigations thus carried out with the mould a patch built up of timber is taken down by the divers and placed over the damaged portion, whilst other divers working inside the hold attach hawsers to the patch to draw it close to the hull plating. The patch is further secured by being bolted to a vertical beam, or several, lowered down the ship's side in the hold. Practically all the attachments of the patch to the hull are carried out from the inside of the ship and so to speak in one operation, instead of being proceeded with gradually and plank by plank as was formerly the case. The result is a quicker, more satisfactory and less dangerous job.

Besides the above ships there were seen in course of salvage in the river one of 6,700 tons built in 1906 and one of over 4,700 tons built in 1908, both of which had been torpedoed. Both, to all appearances, will be ready to resume their service in a comparatively short time.

INDUSTRIAL NOTES.

THE Minister of Munitions does not desire to interfere with such customary holidays as establishements engaged on munitions work think well to give to their employees during the summer and autumn of this year, subject to any special demands which it may be found necessary to make on particular establishments in order to maintain the supply of essential munitions to the front. Firms, therefore, should notify their appropriate Supply Departments of the holidays which they propose to give to their workers, and the Supply Departments will then inform them immediately whether they can or cannot definitely approve of their proposals, and in the latter case will notify them at the earliest possible moment what modifications they require. The Minister also desires it to be understood that employers in forwarding their proposals for the holidays of their workers should so far as is possible take into account any previous holidays which may have had to be cancelled during the current year.

The following are some recent decisions given by the Committee on Production on cases which have been referred to them by the Ministry of Labour, including cases arising out of the Orders under which a bonus to Munition Workers has been given:

Building Trade, Sheffield.—Allowances such as travelling time or walking money, lodging money, outworking allowances, &c., are not to be regarded as earnings in calculating the amount upon which the 12½ per cent. war bonus on earnings is paid.

Dock Workers, Glasgow.—The men concerned (checkers, tallymen, measurers, receipt takers and time keepers) are to receive a further war advance of 7*s.* 6*d.* a week in satisfaction of any claim to the 12½ per cent. bonus on earnings.

The Insurance Commissioners have had under consideration the effect of war bonuses, and other increases in remuneration due to war conditions, on the position of persons insured under the National Insurance (Health) Acts. A person employed otherwise than by way of manual labour is not required to be insured under those Acts in respect of his employment if his remuneration is at a rate definitely exceeding in value 160*l.* a year or an equivalent rate where part-time service only is involved.

Hitherto the view has been taken that war increases in remuneration might, in most cases, be regarded as merely temporary in character, and that an employed contributor who receives a war bonus bringing his remuneration for the time being to a rate exceeding 160*l.* a year does not necessarily cease to be insurable as an employed contributor, but contributions should be paid by the employer so long as the level of the remuneration, estimated on a reasonable average, does not exceed that rate.

It appears to the Commissioners that the time has arrived at which increases in remuneration given in view of circumstances arising out of the war have become so general and have assumed such a character that they may ordinarily be considered as being definitely a portion of the employed person's remuneration. The effect of this view would be that an employer would not be required to pay contributions in respect of a non-manual worker whose remuneration, inclusive of the war increase, exceeds the rate of £160 a year.

Accordingly it is proposed that after the termination of the current half-year (ended June 30) a war increase shall be regarded as a definite part of remuneration for the purposes of Schedule I, Part II (*g*), to the National Insurance Act, 1911, unless in any special case its grant is definitely limited to a certain restricted period. Cases of doubt may be submitted to the Commissioners for decision under Section 66 of the Act of 1911.

It should be noted that under the provisions of Section 13 (1) of the National Health Insurance Act, 1918, an insured person who ceases to be employed within the meaning of the Acts on or after the July 1, 1918, will remain entitled to benefits, subject to the ordinary conditions, for a year after the end of the week in which he ceased to be so employed.

Attention is also drawn to the provisions of Section 7 of the Act of 1918, under which a person who has been employed within the meaning of the Acts and insured as an employed contributor for 104 weeks or more and ceases to be an employed contributor is entitled, as from July 1, 1918, on giving proper notice, to be insured as a voluntary contributor, paying contributions at the employed rate, *i.e.*, 7*d.* a week (in Ireland, 5½*d.* a week) for a man, or 6*d.* a week (in Ireland, 4½*d.* a week) for a woman. (The rate payable in Great Britain is reduced by 1½*d.* a week where the voluntary contributor is not entitled to medical benefit because his total income from all sources has been found to exceed 160*l.* a year. It does not, however, follow that this would necessarily be the case on the rate of his remuneration being raised to over 160*l.* a year.)

The annual ordinary general meeting of the British Cyanides Company, Limited, was held in London, on June 26, the chairman of the Company, Mr. C. F. Rowsell, presiding. After dealing with financial matters, Mr. Rowsell stated that the company, in association with the North Lincolnshire Iron Company, and others, had combined with the Government to form a company to develop the potash industry on the lines indicated by Mr. Leigh and Mr. Chance, and he was glad to state that by careful organisation they had been able to undertake, in conjunction with the Government Potash Branch, the development of this most important and vital product without interfering with the progress of the company's other work.

Mr. Kenneth M. Chance, managing director, who followed, said that during the past year the requirements of Government departments had been urgent and insistent for the production by the company of new chemical compounds, and a largely increased production of some of those compounds the manufacture of which had been undertaken by the company during the last two or three years. Mr. Chance added that in practically all the new products which the company are making and have in view, their ultimate aim is to capture and hold all that was formerly monopolised by Germany. So far as he was aware, the manufacture of permanganate of potash had been previously carried out on a large scale in this country, and the manufacture of red prussiate of potash was confined to Germany for many years prior to the war. The company were now making the latter chemical on a scale sufficient not only to meet the requirements of this country, but to permit of export to our Colonies and Allies; they were making permanganate of potash in large and increasing quantity. The standards of purity they had reached in these chemicals were at least as high as, if not higher than, anything reached by the Germans. In the manufacture of pure carbonate of potash they were told that their product possessed qualifications which were superior to any hitherto purchased from Germany. They were, of course, making other chemicals, and up to the present, research work in the laboratory had kept well ahead of developments in the factory, so that they had new processes waiting for them to take up for the manufacture of still more products whose secrets had hitherto been jealously guarded by Germany.

ROYAL INSTITUTION.—A general meeting of the members of the Royal Institution, was held last Monday afternoon (the 1st inst.), Sir James Crichton-Browne, J.P., F.R.S., treasurer, in the chair. Thomas Glover was elected a member. His Grace, the Duke of Northumberland, was elected president, and Sir Thomas Wrightson, Bart., was elected a visitor. The treasurer announced that the managers at their meeting had appointed Sir James Dewar, F.R.S., Fullerian Professor of Chemistry,

ALUMINIUM PISTONS FOR AEROPLANE ENGINES.

WE have received from Lieut.-Colonel J. G. Weir, the Controller of the Technical Department—Aircraft Production, Ministry of Munitions—the following interesting report:—

Report on Aluminium Pistons from 230 Horse-Power Benz Engines.

A 230-horse-power Benz engine, No. 31,560, taken from the Aviatik biplane, G. 130, captured on February 12th, 1918, was found to be fitted with aluminium pistons. As these are the the first aluminium pistons to be found in a captured enemy aero engine in service, a detailed report of their design, together with a chemical analysis of the alloy, should be of interest.

The pistons weigh 4 lb. 8¾ oz. each, without rings, which weigh 1.5 oz. each. The total weight of the complete piston, with rings and gudgeon pin set screw, is 4 lb. 14½ oz., as compared with the standard cast iron piston, which weigh 6 lb 11½ oz. The gudgeon pins and connecting rods are of standard Benz design, as also is the rest of the engine to which these pistons were fitted.

The design of the standard cast iron Benz piston, which is fitted with a conical steel support, riveted to the inside of the piston crown, and which bears upon the centre portion of the gudgeon pin through a slot cut in the connecting rod small end, is well known. Unlike the standard cast iron piston, the domed head of the sand-cast aluminium piston is supported and strengthened by eight webs radiating from a central boss in the piston crown. The formation and shape of the webs is clearly shown in the photographs and sectional drawings of the piston.

Three cast iron rings are fitted above the gudgeon pin and one scraper ring is provided below the gudgeon pin. All rings are concentric and are machine hammered on the inside. It will be noticed that the rings are exceptionally deep in section, being 5·25 deep and only 3 mms. wide vertically. The piston ring gap measured in position in a standard 230 h.p. cylinder was found to be exceptionally wide, *i.e.*, 1·9 mm.

As may be seen in Fig. 2, the gudgeon pin bosses are fitted with steel bushes 2 mms. thick. These are cast into the bosses in the usual way. The gudgeon pins are 38 mms. diameter, and the gudgeon pin bosses are 65 mms. diameter. The method of fixing the gudgeon pin by a hexagon headed set screw and split pin is standard Benz practice. An annular semi-circular groove 4·5 radius is machined on the bottom lip of the piston, as shown in the section drawing, Fig. 3, and the inside of the skirt is machined inside up as far as the reinforcing rib of the scraper-ring directly below the gudgeon pin.

Further details of the design of these aluminium pistons are shown in the illustrations, and the chemical composition of the alloy from a metallurgical analysis carried out at R.A.E., is as follows:—

	Per cent.
Copper	6.02
Zinc	12.13
Iron	1.42
Silicon	0.31
Tin	Nil.
Nickel	Nil.
Manganese	Trace.
Magnesium	Trace.

As the engine from which these pistons were taken was found to be too badly damaged to carry out a test, it has been impossible to ascertain the increased relative efficiency between this engine and the standard 230 h.p. Benz. The compression ratio, however, is apparently slightly higher in the engines fitted with the aluminium pistons, and as will be seen in the detailed drawing of the cast-iron Benz piston, which is given in Fig. 4 for reference, the distance between the top of the piston and the central axis of the gudgeon pin is increased from 70 mms. to 71 mms., which gives approximately 16.51 cubic cms. less in the clearance volume of each cylinder in engines fitted with these aluminium pistons, which gives a compression ratio of 5.0 to 1 instead of 4.94 to 1.

THE NEW TROLLHÄTTA CANAL: ERRATUM.—We are indebted to a correspondent for calling attention to certain errors in the formulas given in the article on this canal which appeared in our issue of June 14. The last equation on page 656 should read—

$$\frac{1}{G}\frac{dp}{dx} = \frac{Q^2}{\Omega^2}\cdot\frac{1}{2g}\left[\frac{2}{l}\cdot\left(1-\frac{x}{l}\right) - k\left(1-\frac{2x}{l}+\frac{x^2}{l^2}\right)\right]$$

and the first equation on page 657 should read—

$$\frac{p}{G} = \frac{Q^2}{\Omega^2}\cdot\frac{1}{2g}\left[\left(\frac{2x}{l}-\frac{x^2}{l^2}\right) - k\left(x-\frac{x^2}{l}+\frac{x^3}{3l^2}\right)\right]+C.$$

THE LATE MR. ARTHUR THOMAS KEEN.—We regret to have to record the death, which occurred suddenly on June 27, of Mr. Arthur Thomas Keen, J.P., of Harborne Park, near Birmingham. Mr. A. T. Keen, was 57 years of age, and was the eldest son of the late Mr. Arthur Keen, of Edgbaston. He was educated for the legal profession, and was called to the bar, practising in the Oxford circuit, but nine years ago he joined the board of Messrs. Guest, Keen and Nettlefold, and on his father's death, became chairman. Mr. A. T. Keen was also a director of the London City and Midland Bank.

PISTONS FOR THE BENZ AERO ENGINES.

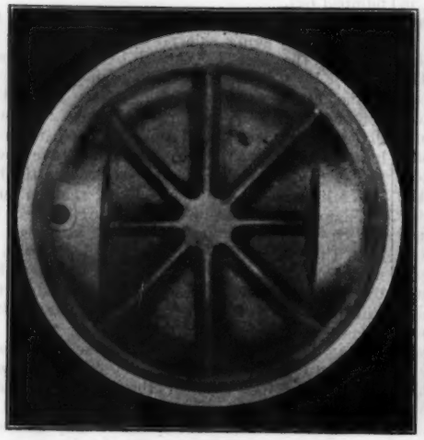


FIG. 1. INSIDE VIEW OF 230 H.P. BENZ CAST ALUMINIUM PISTON.

FIG. 2. SECTIONAL VIEW OF ALUMINIUM PISTON SHOWING FORMATION OF RIBS.

Fig. 3. DETAILS OF ALUMINIUM PISTONS NOW USED IN 230 H.P. BENZ ENGINES.

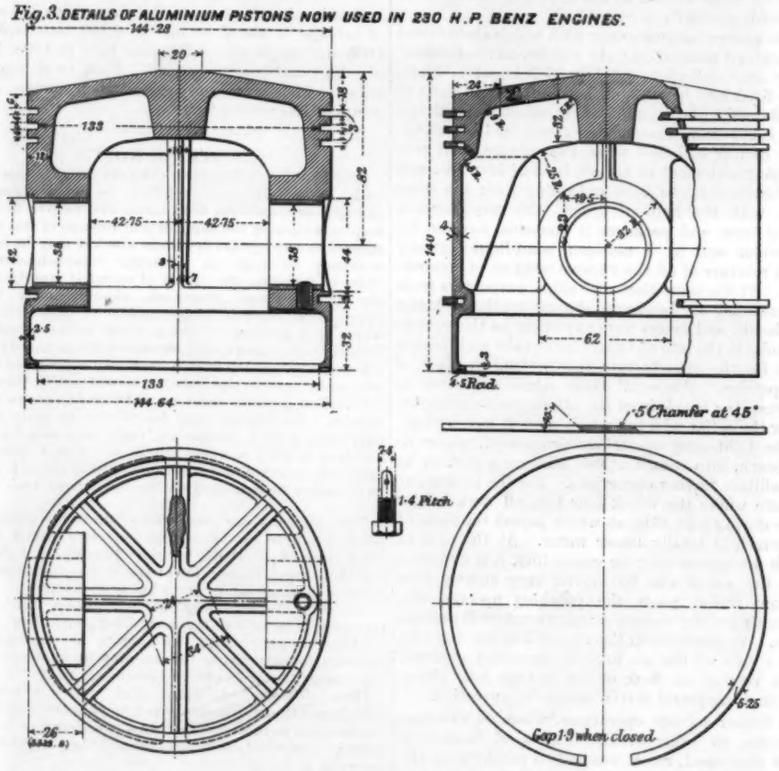
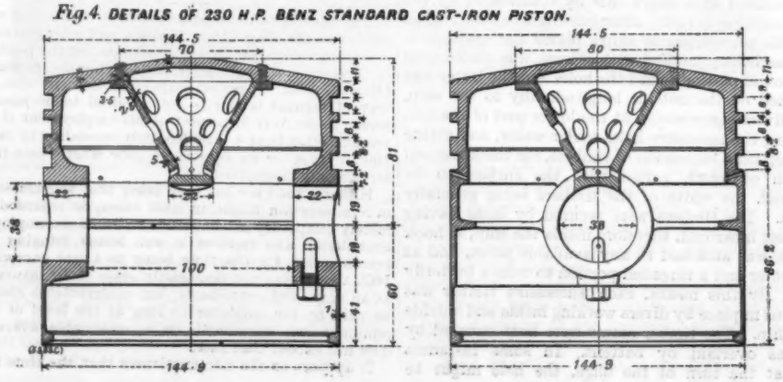


Fig. 4. DETAILS OF 230 H.P. BENZ STANDARD CAST-IRON PISTON.



AIR RAID SIGNALLING SYRENS.

We illustrate in the views, Figs. 1 and 2 on the present page, the Chollet rotating vanes and the series of horns forming the syrens which are now mounted on the monuments of numerous French towns to warn the population of the approach of enemy aircraft. The syren consists of a casing, or stator, inside which revolves an aluminium rotor (see Fig. 2) mounted on a shaft provided with ball bearings. The stator has a number of openings, generally rectangular, whilst the rotor has also a number of openings of the same shape. Vanes for canalising the air start from the centre of the rotor and end at the rotor openings. When the rotor revolves, the centrifugal force drives the air from the rotor towards the openings and through the openings cut in the stator. The flow of air is thus alternately permitted and interrupted, each opening in the rotor driving air through each opening in the stator in succession. Hence the vibrations of the system vary in

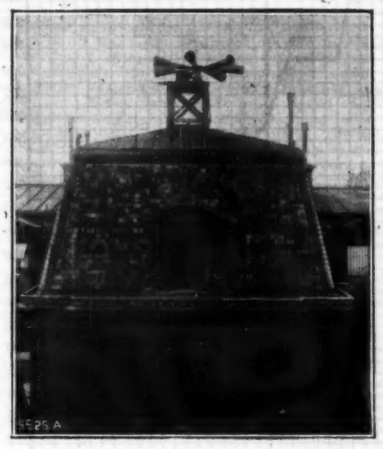


FIG. 1.

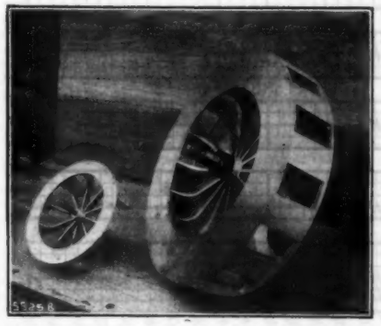


FIG. 2.

number with the number of openings of the rotor. The rotor is actuated by means of an electric motor coupled to the rotor shaft, the system being operated at a distance by means of switches, starting rheostats being used for the large types which require from 12 to 15 horse-power.

In order to amplify the sounds, conical horns of suitable shape and length (shown in Fig. 1) are connected to each opening in the stator. The Paris syrens have a total weight of 800 kg. (about 1,700 lb.); their aluminium rotor is 0.5 m. (19½ in.) in diameter, the horns being 2 m. (6 ft. 6 in.) in length and 0.5 m. in diameter at their mouth. In the open, they can be heard at a distance of 8 to 10 kilometres (about 6.2 miles), but in Paris, owing to the noise in the town, the range does not exceed a radius of 1.5 kilometre (just under 1 mile).

In one type of Chollet syren, all the sound waves are sent in one and the same direction. In this, the syren is fitted at the bottom of a megaphone horn. But the device is very frequently mounted upon a pivoting frame for facing all directions in turn, as obtains with a revolving light. There are syrens of this type in which the horn has a length of 3 m. (9 ft. 10 in.) and a diameter of 1.5 m. (4 ft. 11 in.) at the mouth; they weigh each about 1 ton, and the rotor, which is operated by a 10 h.p. electric motor, has a diameter of 0.5 m. (19½ in.) at the mouth.

Hand operated syrens have also been built in large numbers for giving the alarm to small towns close to the front and to various depots; they are on the same principle as the electrically driven ones, but their range of sound covers a radius of 400 to 500 m. (about 540 yards) only.

AERONAUTICAL INVENTIONS.

The Air Ministry wishes it to be known that the Air Inventions Committee, which was formed about nine months ago, has now received and examined upwards of 5,000 inventions and suggestions relating to the Air Service. It is regretted that, owing to war conditions, a detailed account of their investigations cannot be published, but the experience of the Committee indicates that it may be possible to publish certain information, which will facilitate the work both of the inventors and of the Committee.

The following statement has been drawn up with this object in view, but it is realised that it is incomplete for the reason just given. It is appreciated also that inventors are placed at great disadvantages in present circumstances, for, unless immediately connected either with the Air Services or with aircraft manufacture, it is almost impossible that they should be acquainted with the most recent developments; so rapid has been the rate of progress that it is difficult, even for those in close contact with the Royal Air Force, to keep abreast of all the latest improvements. Again, it is practically useless for inventors at the present time to submit inventions which would necessarily take a long time to develop, the requirements of war and the conditions of labour and material, making it impossible for the Committee to support proposals of this nature.

Generally speaking, and as far as the period of the war is concerned, no very startling change in the present type of aircraft is anticipated, although improvements in parts and also in details are always possible, and may produce very important results.

The stage of development in construction which has now been reached, is such that major improvements can only be expected from those possessing the requisite scientific and mechanical knowledge, skill and experience. Thus, radical changes in the shape of the wings of aeroplane, the body, and the propellers are only possible after long and patient research carried out in aeronautical laboratories. Again, many inventors have forwarded proposals for helicopters and aircraft of this nature, which, if an efficient design can be produced, would possess certain advantages (but probably not so great as was once imagined); others have suggested flapping wings and rotatory planes. Such schemes do not give any promise of being developed for use during this war, and in any case would require some years of experiment before they could be regarded as practical proposals.

As regards minor improvements, inventors should bear in mind that many details such as turnbuckles, clips, &c., are now standardised, and a change would only be justified by some very marked superiority.

Safety devices for preventing crashing of the machine and the pilot form a numerous class. The chief of these is the parachute, either applied by a harness to the pilot or directly attached to the machine. Those who have seen a passenger dropped by a parachute from an aeroplane for exhibition purposes, often fail to realise the conditions under which a parachute may have to be used as a safety appliance. Then the machine may be out of control, dropping at a velocity of 150 to 200 miles per hour, or spinning downwards in flames. Many other safety devices, such as automatic stabilisers, windbrakes, &c., have been proposed at various items. The additional weight entailed by the use of any of the suggested safety appliances must remain a very serious factor for so long as war conditions prevail.

The engine is the heart of the aeroplane, and on its reliability depends the safety of the pilot. Persons acquainted only with motor-car engine practice sometimes do not realise the exacting conditions under which an aeroplane engine must work. The engine must be capable of running for the whole of the time of flight at its maximum power. The lubrication and ignition must be perfect, and the engine must not become overheated. The rating applied to aeroplane engines is its weight per horse power, and engines are now being produced which show surprising results in this respect. Inventions which differ radically from present-day practice (such as the internal-combustion turbine) have small possibilities of being adopted, for successive design and reconstruction entailing probably several years' work are necessary before satisfactory results can be hoped for. In view of the shortage of materials and labour at the present time, no new type can be embarked on, unless it is demonstrably superior to existing types, and possessed of definite and immediate advantages over them.

A subject which is intimately connected with the power-plant, is its noise. This constitutes one of the disadvantages of an aeroplane. For night flying, a method by which it would be possible to hear from one aeroplane, the approach of another, would be of great advantage. The engine can be silenced without serious disadvantages, but the noise of the propeller and the hum of the wires are so great that silencing the engine is not sufficient.

Many proposals for the projection of bombs and grenades of flame, and of poisonous gases have been received. The trailing bomb or grapnel for attacking enemy aircraft and submarines is a favourite suggestion from inventors. This device was tested before the war, and at various times since, but has been abandoned in favour of more effective methods.

Instruments.—Many hundreds of inventions and suggestions for inclinometers and instruments for straight flying and accurate bomb-dropping have been investigated. Efficient and well-designed instruments for these purposes have been available for some time past, but it is quite possible that improved forms may be produced, though it is scarcely likely that this can be done by anyone who does not possess the necessary scientific and mechanical knowledge required for an investigation of this nature. Some inventors entirely disregard the action of centrifugal force upon pendulum and spirit-level devices.

A large number of gyroscopic instruments have been proposed which show insufficient knowledge of the correct application and limitations of a gyroscope.

Anti-aircraft devices of various kinds are constantly suggested, but now contain very little new matter for consideration, as such proposals have received the careful attention of the authorities for a long time past, and have been the subject of much trial and experiment. Any proposals of a practical nature which contain features of novelty, and may be of utility, are discussed with the assistance of the Air Service.

The Committee fully appreciate the genuinely patriotic motives which inspire most of the communications which they have received, and it is with the object of encouraging the submission of useful and well-considered proposals that this statement is issued. Inventors should, however, bear in mind that the somewhat obvious proposals which might have been useful in an earlier stage of the war, are now no longer serviceable. By following the general tenor of the above suggestions, inventors will greatly assist the Committee in the execution of their responsible duties.

Agricultural and Dairy Machines Order.—The Minister of Munitions has issued an Order dated June 21, providing that on and after July 1 no person may sell or deliver any agricultural or dairy implement not purchased by him direct from the manufacturer unless he holds a permit for such sale. A further clause provides that no person may sell or deliver any such implement at a price exceeding by more than 17½ per cent. the net cost paid by him where such net cost is 40*l.* or over, or by more than 25 per cent. where less than 40*l.* But this latter provision does not apply to any agricultural implement at a price not exceeding 2*l.*, to any dairy implement not exceeding 1*l.*, nor to any part of such implement not exceeding 10*s.* The purchase of any other article may not be made a condition of sale of an implement. Dealers must keep records of sales, &c., and make such returns as may be required. The expressions "agricultural implement" and "dairy implement" mean any machine, implement, vehicle or other article or part designed, adopted or commonly used for agricultural or dairy purposes respectively, but no second-hand vehicle, &c., is included. Applications for permits so far as England, Scotland and Wales are concerned should be addressed to the Director, Agricultural Machinery Department (price control Section), Ministry of Munitions, 8, Northumberland-avenue, W.C. 2, and those for Ireland to the Department of Agriculture and Technical Instruction, Upper Merrion-street, Dublin. In conjunction with the Order the Minister of Munitions has taken steps to control the prices chargeable by manufacturers for all such machinery and implements, and no manufacturer will be allowed to receive any part of the percentages referred to above which are chargeable in addition to the manufacturers' prices, to cover agency, distribution and other selling expenses.

Motor Car Distribution in Europe.—The Fiat Company state that the number of motor cars in use in Europe is 522,112, according to figures compiled by the Fiat Press Bureau. Great Britain heads the list with 171,607 cars for 1917, Germany coming second with 95,000 cars in 1914, the last year for which statistics are available. France is third on the list, and Italy fourth. Generally the returns are for touring cars only, and do not comprise lorries and motorcycles. England's returns are lower for 1917 than they were for 1914. Yet England has added very considerably to her number of commercial motors by reason of the war. The French returns are always under-estimated, being based on actual taxes paid, and do not include taxicabs, lorries, or motorcycles. Before the war, the actual number of privately-owned motor vehicles in France was about 115,000. Since then, it is estimated that France has imported or built 80,000 war motors. The principal battle front being in France, there are actually more motor vehicles in that country at the present moment than in any other in Europe, for, in addition to those of the French Army the number includes those of the British, American, Italian, Belgian and Portuguese forces. The record for the number of cars per head of the population is held by the Principality of Monaco, with one car for every 95·6 inhabitants. England comes second, with one for 268·5, while Denmark takes third place, with one for 343. France just beats the British possession, Gibraltar, for fourth place, the respective figures being 402 and 411. The country with the smallest number of cars, and also with the greatest number of inhabitants per car is Crete, which is officially returned as having three cars, or one for 121,666·6 inhabitants. Geographical conditions are, of course, an important factor in determining the proportion of cars. Italy, with its vast mountainous region, can never have the same number of cars as comparatively level England, although both are important car-producing countries. Unfortunately, Serbia had a lot of leeway to make up even before the war, while Austria-Hungary does not stand high as a motor country.

TRADE AFTER THE WAR.

ELECTRIC ENGINEERING AND ACCESSORIES.

THE Departmental Committee appointed by the Board of Trade to consider the position of the electrical trades after the war, especially in relation to international competition, has issued its report (Cd. 9072), signed by Messrs. Sir Charles A. Parsons (chairman), J. Annan Bryce, Sir T. O. Callender, James Devonshire, Bernard Mervyn Drake and Sir John Snell. Mr. James F. Ronca acted as secretary.

"The approximate annual value of the total products of electrical plant, mains and appliances in Great Britain and Germany respectively are set out in the following table :—

	Britain.	Germany.
	£	£
Total electrical products	22,500,000	60,000,000
Exports	7,500,000	15,000,000
Imports	2,933,000	631,000
Consumption of home-made machinery ...	15,000,000	45,000,000 "

This is the only statistical information given in the report, and no authority is quoted for total value of production. Other engineering committees complain that no production statistics are available, and give the source and details of their estimates of production.

Evidence was given that 32 electrical firms with an aggregate initial capital of 15,000,000*l.* had been obliged to write off 3,125,000*l.*, and that few of these companies ever earned a satisfactory return on their capital. Cable-making has been an exception, having been successful in trade and financial results. A large proportion of the home production has been done by firms under foreign control. It is stated that "a factor retarding electrical progress in Great Britain has been the strength of the gas interests and the influence they exerted to stifle competition." At the outbreak of war Germany was negotiating for financial control in existing companies in the United Kingdom, Dominions and India. There is conclusive evidence of German control over companies ostensibly British and German influence against British interests has been used indirectly through companies incorporated in America, Switzerland and other countries. British financiers have not helped British industry and have allowed themselves to be exploited for the benefit of German industry. Railway and shipping facilities have also been used to favour German at the expense of British industries. In all these matters the careful citation of statistical and other evidence given by the other engineering committees in support of their statements is omitted entirely.

The committee complain of the delays, uncertainties and variety of official procedure necessary to sanction electrical enterprises or extensions and on this matter are in accord with the electrical supply committee.

"Witnesses of high authority estimate the loss incurred by the nation through failure to take full advantage of electrical progress at not less than 100,000,000*l.* a year, a loss preventable by concentrating generation under improved administration." No information is given in the report as to who these witnesses were or the basis or outlines of their estimates.

The committee recommends :—

1. Protective duties high enough to be effective. Prevention of sale in this country of any imported electrical goods at prices lower than those current in the country of origin. Prohibition of transport discrimination. Prohibition of alien control of our natural sources of power.

2. State departments, public bodies, and companies supplying current under statutory powers, to accept British tenders only. Reform of Acts and regulations affecting electric supply.

3. Imports of enemy goods to be prohibited for three years after the war, subject to licence in special circumstances after one year. No enemy-controlled company to trade within the Empire except under licence and publication of its constitution. Enemies not to hold more than 25 per cent. of the capital of any electrical company. Goods produced in any foreign country by companies controlled by enemy capital or direction to be treated as enemy goods.

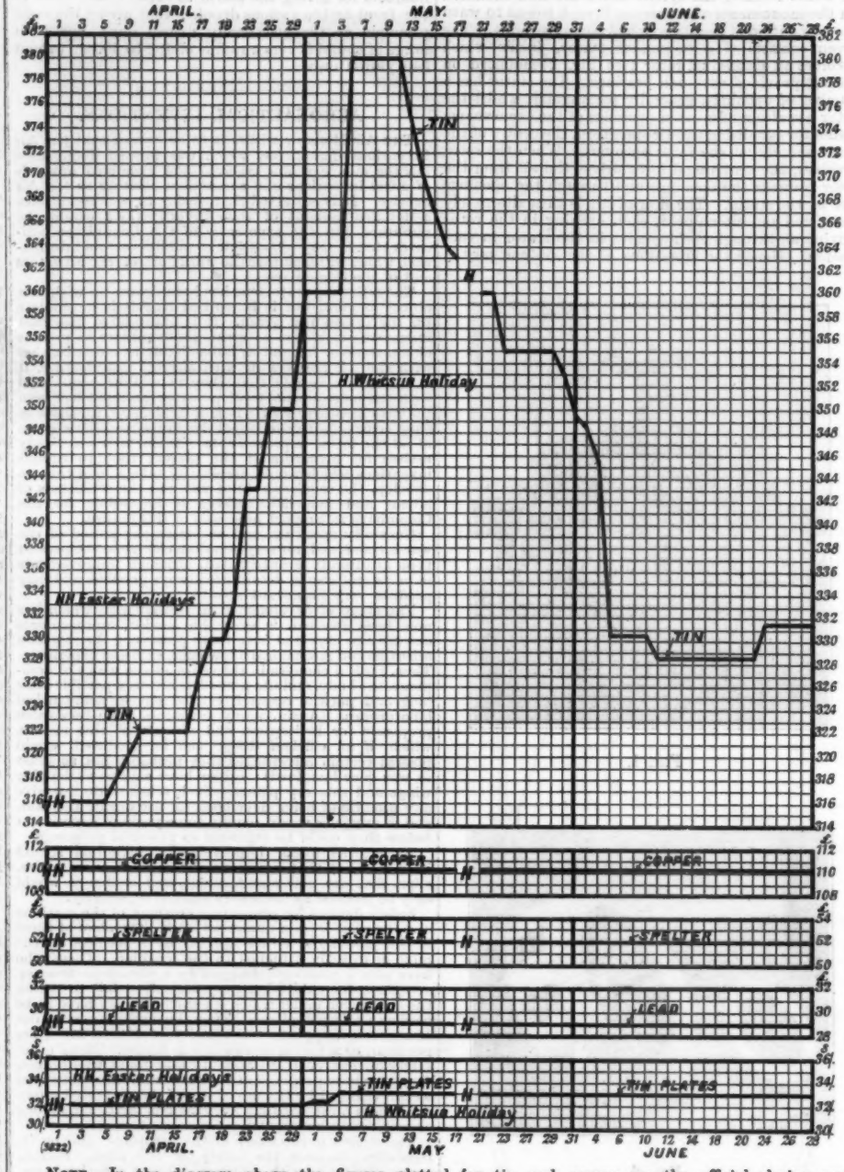
4. Combination of manufacturers with official co-operation. Extended banking facilities, preferably through industrial banks.

The committee intends to deal with education, research, decimal system, consular service, &c., in a further report.

THE LATE MR. W. PERREN MAYCOCK.—We regret to record the death, on June 29, at the comparatively early age of 52, of Mr. W. Perren Maycock. Mr. Maycock was a member of the Institution of Electrical Engineers, and wrote a number of books on electric subjects. His works were deservedly popular, as he had the gift of clear exposition. He could make electric phenomena intelligible without the aid of mathematics, or, at least, without going deeper into mathematics than the average engineer could follow without difficulty. He never slurred over the recondite points, but set himself to make them as definite to his reader as they were to himself. Hence, when the student closed the volume, he felt that, so far, he was on sure ground, and that there were no unexplored patches behind him that he could not penetrate. Of course, the whole field of electric service cannot be covered by such methods, but that portion of it which is of interest to the practical man may be, and many will learn with regret that they cannot look forward to further enlightenment from the same source, except from one small book on electric motors, passed for the press just before the death of Mr. Maycock. The deceased leaves a widow and two young sons.

DIAGRAMS OF THREE MONTHS' FLUCTUATIONS IN PRICES OF METALS.

(Specially Compiled from Official Reports of London Metal Markets.)



NOTE.—In the diagram above the figures plotted for tin and copper are the official closing cash quotations of the London Metal Exchange, as far as they have been reported, for "fine foreign" and "standard" metal respectively. The prices shown for lead are for English metal, whilst those for spelter are for American metal. The prices are per ton. The price of tin-plates is per box of I.C. cokes free on board at Welsh ports. Each vertical line in the diagram represents a market-day, and the horizontal lines represent 1*l.* each, except in the case of the diagram relating to tin-plates, where they represent 1*s.* each. On July 7, 1916, the Minister of Munitions issued a list of maximum prices and regulations governing the dealing in certain metals, &c.; thus the price of hematite pig iron was fixed at 6*l.* 2*s.* 6*d.*, Scotch at 5*l.* 14*s.*, and Cleveland at 4*l.* 11*s.* 6*d.* per ton. Ship-plates were priced at 11*l.* 10*s.*, and heavy steel rails at 10*l.* 17*s.* 6*d.* per ton. These quotations are still in force. (For official regulations see page 45, vol. cii.)

BRITISH MERCHANT SHIPBUILDING OUTPUT.—The secretary of the Admiralty announces that the tonnage of merchant vessels completed in United Kingdom yards, and entered for service during June, 1918, was 134,159 tons, making a total of 1,431,150 tons from July 1, 1917, to June 30, 1918. The Controller-General of Merchant Shipbuilding makes the following comments in this respect :—"It is encouraging to note that during the quarter ending June 30 this year, the tonnage of merchant ships completed in this country shows an increase of 78 per cent. over the figures for the corresponding three months ending June 30, 1917.

PERSONAL.—The Beldam Packing and Rubber Company, Limited, 29, Gracechurch-street, E.C.3, inform us they have opened a branch office and stores at Castle Chambers, 85, High-street (Town Quay), Southampton, under the management of Mr. R. H. Fleming, R.D., R.N.R. Arrangements have been made to stock their special packings and jointings for quick delivery at this port. Since Monday last, July 1, the address of the Controller of Timber Supplies is 80, Newman-street, Oxford-street, W. 1. Telephone: Museum 4240. Thomas Smith and Sons, Mechanical and Electrical Engineers, Steam and Electric Crane Works, Rodley, near Leeds, state that their business has been converted into a private limited company, and in future they will trade as Thomas Smith and Sons (Rodley), Limited. There will be no change whatsoever in the management. The General Electric Company, Limited, 67, Queen Victoria-street, E.C., state that they have received a communication from His Majesty's Treasury, refusing for the present to sanction the division or issue of the ordinary share capital of this company into shares of a lower denomination than 10*l.* This does not introduce any alteration whatsoever in the programme as set out in the directors' report, except that the denomination of the ordinary shares will remain 10*l.* instead of 1*l.*

SOME OUTSTANDING PROBLEMS IN AERONAUTICS.*

By DR. DURAND.

(*Concluded from page 732, vol. cv*).

Maintenance of Power at Altitude.—We come now to a problem of the very highest present and future importance, that of maintaining the power of the engine at high altitude.

The situation as it develops in the case of an aeroplane mounting to higher and higher levels in the atmosphere is readily appreciated with a moment's thought.

The power of the engine arises from the combustion of vapourised hydrocarbon fuel. The power per cycle for a given cylinder will therefore, to a first approximation and assuming a sensibly constant efficiency of thermodynamic transformation, vary directly with the weight of the fuel which can be burned per cycle. But this in turn depends upon and is conditioned by the amount of oxygen which can be drawn into the cylinder per intake stroke of the cycle. But the oxygen is brought in as one of the constituents of the atmosphere and hence the amount of oxygen available per intake stroke will depend upon and be directly proportioned to the amount of air which can be drawn in. But in terms of volume, just a cylinder full or more exactly, just the volume represented by the piston displacement in moving from one end of the stroke to the other, can be brought in. Hence, we may at least depend on what we may term a cylinder volume of air no matter where we are. But just here arises the trouble. The actual weight of air depends conjointly on the volume and on the density, and unfortunately for the aeronautic engine, at least, the density of the atmosphere decreases steadily with altitude, so that at 15,000 ft., for example, the density is only about 60 per cent. of the normal density at the earth's surface. It is clear then that an aeronautic engine, other things equal, will draw in, per intake stroke, only about 60 per cent. of the weight of air at this altitude as compared with the indraft at the earth's surface. Hence, it will be able to burn only 60 per cent. of the fuel and hence with equal efficiency will develop only 60 per cent. of the power.

But here we must stop for a moment and inquire as to the effect of such reduction of power on the speed of the aeroplane. We know that, other things equal, the resistance of an aeroplane to propulsion through the air at uniform speed varies directly with the density of the medium. Hence, at the same speed as near the surface of the earth and with the same altitude or angle of attack, the aeroplane at 15,000 ft. elevation would experience only 60 per cent. of the resistance and would hence require only 60 per cent. of the thrust, and hence at constant revolutions of the propeller would require only 60 per cent. of the power from the engine. Hence, it appears at first sight as though we had lost nothing in speed by the reduction of the power of the engine. If the latter has been reduced to 60 per cent. of its amount at low levels, so has the resistance and power required so that the speed realised should remain the same.

Such would, indeed, be the case if this were all of the story; but, unfortunately, other considerations enter and the simple relation of uniform speed at varying altitudes cannot, as a matter of fact, be realised without compensating features. Thus, if at a constant speed and constant angle of attack for the wings, the resistance to propulsion is only 60 per cent. as great at the altitude of 15,000 ft. as on the ground, it is, unfortunately, the same for the lifting force developed by the wings. This also is only 60 per cent. as great, while the weight of the machine remains sensibly constant at all altitudes. Let us pause long enough to grasp clearly this fact, that while, at constant speed and attitude of flight, the resistance, the lift and all other aerodynamic forces involved vary directly with the density of the air, and hence decrease with the altitude, the weight of the machine, and hence the lift necessary for support, remain sensibly unchanged. Hence, at the same attitude of flight the lifting force at altitude and under the same speed will no longer support the plane, and unless something is done, it would be unable to maintain horizontal flight at such altitude.

Two courses are then open for consideration as follows:—

1. We may seek to increase the speed until at such increased value the lift will equal the weight of the plane. Under the conditions assumed, this would involve an increase of speed of about 30 per cent., thus increasing the resistance to propulsion by nearly 70 per cent. or bringing it back to its value at low altitude. But this resistance overcome at the increased speed would mean an increase in the required horse-power of 30 per cent. as compared with that normally developed at low level, while with the actual indraft of air and even allowing for the increased speed, only some 78 per cent. of this, or 60 per cent. of the needful amount would be developed. Hence, no such speed could be realised, and the support of the unvarying weight in the rarefied air cannot be realised in this manner, and must be sought otherwise.

2. Instead of seeking for the necessary lift by increased speed we may seek it by changing the angle of attack; by changing the flying attitude of the plane so that at the same speed, for example, the lifting force will be greatly increased. In this manner the needful lifting force may indeed be realised. But unfortunately with the increase in lifting force will come also an increase in head resistance, not proportionally, but still a definite increase. This will mean that the actual resistance at, say, 15,000 ft. elevation will be greater than 60 per cent. of that at low elevation and hence with 60 per cent. of the power available per cycle, the original number of revolutions cannot be maintained and a reduction in speed will result. With this reduction in speed will come a further loss in lifting effect and need for a further change in the angle of attack with increased head resistance; until finally, at some reduced speed, a condition will be found where the needful support for the weight of plane may be realised and the resistance to propulsion can be met by the thrust or pull developed by the propeller. Under these conditions, horizontal flight again becomes possible, but at a speed somewhat below that corresponding to low altitude conditions.

But this is not all of the story. In addition we must reckon on a diminished efficiency of the engine with decreased power, and with the probability of a loss in propeller efficiency with the resultant change in speed. Thus, if an engine is primarily designed to work at its best efficiency and under its best conditions at or near full atmospheric pressure and density, it will not work with equally good efficiency at high altitudes in rarefied air and when developing only about one-half the power for which it is primarily designed.

All of this means, in brief, then, that at an altitude of, say, 15,000 ft., the plane must fly at a less advantageous angle of attack and hence with more resistance, and that the engine will be able to burn only about 60 per cent. as much fuel and will transform the resulting heat less effectively than when at low altitudes. Hence, the power developed will be less than 60 per cent., and hence, insufficient to maintain the same speed; and with diminishing speed there may be further loss of efficiency in the propeller and a further loss of speed until finally matters become adjusted at some value usually definitely and sometimes considerably less than that corresponding to low-level conditions.

Hence, as an overall practical result an aeroplane normally loses horizontal speed as it ascends to higher altitudes. Confronted with this fundamental fact, what is to be done? Such loss of speed, especially in a military sense, is or may become very serious, and one of the large and definitely outstanding problems in aeronautic engineering at the present time, centres about the possible ways and means of meeting this condition. The obvious proximate solution is to avoid, so far as may be, the decrease in the amount of air handled per intake stroke of the piston as the plane ascends to higher and higher altitudes. Broadly, two courses are open. First, we may definitely and frankly design the plane and engine for a certain desired performance at a given altitude, say 15,000 ft. to 20,000 ft. This is a straightforward problem in aeronautic engineering. Given the desired schedule of operation and the altitude, we can determine the resistance to be overcome and the horse-power required, and can design the engine accordingly. In such case the volume of the cylinders will be suited to the rarefied air in which the engine is to work, and all proportions and details will be worked out on this basis.

It will be obvious that such an engine will have much too large a piston displacement volume when at low altitude. That is, it will be over size and over powered relative to the plane. In fact, operation near or on the ground under the same adjustments as at altitude would be quite out of the question. Means must therefore be provided for reproducing, when on the ground or at low altitudes, substantially the operating conditions at high altitudes and low air density; that is, the conditions for which the engine was designed. This may be most conveniently done by throttling down the air intake so that while air at or near full sea-level density may surround the engine, it will be reduced in pressure at the intake throttle to such a degree that the amount actually taken into the cylinder will only equal that which would normally enter, without throttling, at high altitude.

On the other hand, we may definitely design the engine for operation at or near sea-level and with size of cylinders and all proportions and adjustments worked out accordingly, and then by a supplementary device endeavour to maintain or nearly to maintain such conditions within the engine itself even if it is at high altitude and surrounded by air of a lower density. This solution calls for some supplementary form of compressor or equivalent device which shall operate on the rarefied air as a first stage and raise it from the low pressure, characteristic of the altitude, up to or nearly to normal low-altitude pressure and density.

Each of these alternatives represents a perfectly possible solution. Each has its special advantages and disadvantages. Each has its advocates as a solution of this important problem. The first solution is the simpler of the two, since it involves no special or additional device for compressing the air. It does, however, mean extra weight in the engine which is always there and which will reduce correspondingly the net carrying capacity of the plane.

On the other hand, the compressing device of the second solution is not easy to realise satisfactorily, and it also involves extra weight, though presumably less than in the case of the first solution. Again, its operation as a separate or independent unit for realising a preliminary compression of the air is less efficient than to do the whole compression in the engine itself and by the engine piston as in the first solution. Only extended and careful trial will presumably be able to finally decide which is on the whole the better solution of the two.

The reserve necessary with regard to military matters makes it unwise to attempt to give any account on this occasion of just where the matter stands with regard to this problem, but it will at least be safe to note that it is a problem which is attracting much attention and study on the part of the various allied Governments, and that much valuable information is being developed, and on which we may hope that some satisfactory solution may be based.

The Airscrew.—We shall now turn our attention for a few moments to one of the most intricate and hence one of the most interesting of the many problems presented to us by the aeronautic art, that of the airscrew or propeller.

The function of the airscrew is, of course, to take the torque of the engine and to transform it into a propulsive thrust; or otherwise to take the power given by the engine to the crankshaft and transform it into driving or propulsive power for the aeroplane. The problem is further complicated by the fact that expressed in terms of a power relation, it is not simply the question of an engine handing so much power over to the airscrew for the latter to transform into propulsive power. Instead, the power which the engine itself can develop is dependent on the propeller and likewise on the aeroplane to which they are both attached. We have here, in consequence, a series of complicated implicit relations, from which the propulsive characteristics of the plane-propeller-engine combination take their origin. In fact, it must never for a moment be forgotten that the moving aeroplane is in effect an aeroplane-motor-propeller combination and that no one of the three can be determined independent of the other two.

Without entering into any detailed discussion of this problem, it will be clear that the airscrew will exercise a controlling influence on the power which the engine can develop. Thus, it is evident that an aeronautic engine, in order to develop power, must be permitted to move its pistons, to revolve its crankshaft, in other words, to make revolutions; and other things equal, the power developed will vary directly with the revolutions which can be realised. Again, it is easy to see that the size and amount of surface of the airscrew blades will present a controlling feature regarding the revolutions which can be realised. Thus, the airscrew may be enormously over size, too large in diameter and presenting a large and unwieldy surface to the air. Suppose this to be the case with a plane of size suited to the airscrew but not to the engine. That is, the engine is far too small for either airscrew or plane. In such case the engine simply will not be able to make its normal number of revolutions. It will be held down by the excessive resistance to rotation presented under such circumstances, and may thus develop far less than the normal power which it is capable of under proper conditions. Many other combinations may occur which we cannot stop to discuss or even to mention. Broadly speaking, the plane, the engine and the airscrew, as the propelling agent, form a most closely knit combination, and each interacts in a more or less controlling manner on the operation of the other two.

In order even to make a start with the problem of the airscrew it is therefore necessary to assume conditions regarding both the plane and the engine. If these conditions, as assumed, are then realised in practice and if the design has been well carried out, the anticipated results may be reached. If, on the other hand, the assumed conditions are not realised as regards the plane and the engine, then no matter how well the design of the airscrew may have been carried out, the anticipated results will not be realised. Hence, no matter how good the airscrew may be by itself, no matter how carefully designed and constructed, no matter how faithfully it may be able to realise the conditions for which it is designed, if these are not the conditions under which it is actually placed for service, the results, economic and otherwise, will be unsatisfactory; not necessarily by reason of any fault in the airscrew as such, but due simply to its lack of adaptation to the conditions of operation. An effective airscrew is therefore not only one which is properly designed and constructed in itself, but also one which is permitted to operate under the conditions intended and contemplated in the design.

All this is, of course, well known, and if I have taken the time to repeat these well-known facts, it is the more clearly to bring to our minds at the present moment the fact that the airscrew represents not only a problem in itself, but also one of adaptation to and of usage with the proper combination of plane and of prime mover.

The general problem of the airscrew is by no means, however, to be classed distinctively as outstanding. Instead, an enormous amount of work has been done on it, both theoretically and experimentally, and in its main features it has been brought fairly within the limits of a solved problem. There have been three modes of approach, briefly, as follows:—

1. The analysis, geometrically, of the blade of an airscrew into a series of elements, occupying each a narrow strip running across the blade from leading to following edge and making up, by their summation, the blade as a whole. Each of these elements or strips is then considered as, in effect, a little elementary aerofoil and for which the usual aerodynamic characteristics are readily determined, either by direct experiment on a model, or by selection or interpolation from and among the large amount of available data regarding such aerofoils, which have already been submitted to experimental investigation. With such data in hand relating to the series of elements going to make up the blade, it is a matter of simple computation to combine them in such a manner as to represent the action of the blade as a whole, under the conditions assumed, and thus in general terms the problem is solved.

2. A law of similitude is assumed and a small model propeller is tested out experimentally and under conditions which permit, under the law of similitude assumed, the translation of the observed results for the model into the probable results for the full-sized airscrew.

3. Full-sized airscrews are tested out as nearly as may

* Paper, slightly abridged, read before the Aeronautical Society of Great Britain at the sixth "Wilbur Wright" lecture in the Central Hall, Westminster, on Tuesday, June 25.

be under flying conditions and are made the ultimate basis of design.

The limitations of method No. 1 arise from the following :—

(*a*) The coefficients derived for aerofoils correspond to straight-line motion between the air and the foil, whereas, in the airscrew, the relative motion is in a helical or spiral path.

(*b*) The actual velocities for which such coefficients are derived are usually for speeds not exceeding 60 miles or 70 miles per hour, whereas the actual speeds of the tip elements of airscrew blades may move at speeds of 500 miles per hour and upward. The extent to which the usual square of the speed law may be extended to such values is not as yet fully known.

(*c*) The coefficients used are derived for the various aerofoil sections or elements individually, whereas, in the actual airscrew, they all act conjointly or collectively in making up the airscrew blade.

Application of method No. 1 cannot therefore be made, except in so far as it is justified by actual and final experience on full-sized forms under flying conditions.

Method No. 2 (that with reduced size models) has the limitation that the law of similitude employed is, of necessity, not exact but approximate and the degree of reliance which can be placed on results thus found can again only be determined by ultimate reference to full-sized forms under flying conditions.

Method No. 3 (that with full-sized forms under actual flying conditions) has the limitation of very high cost, both in equipment and time, and as a result of which only a relatively small number of forms can actually be subjected to adequate test in this manner.

Again, method No. 1 (that of computation based on coefficients determined by laboratory experiment) has the advantage of requiring only a pencil and pad of paper with a table of predetermined coefficients. No. 2 (that with the small models) has the advantage over No. 3 of relatively small cost, of permitting the tests to be carried out in a wind tunnel with all conditions under control, and finally to permit of carrying quickly through the test programme a very large number of types and forms. It should perhaps be stated here that as between methods No. 1 and No. 2, the latter is accepted as much the more reliable of the two. In fact, it is not too much to say that when used with judgment it furnishes a very satisfactory and well-nigh universally accepted method for dealing in a laboratory way with most problems of airscrew design and operation.

If we have tarried so long over these phases of the problem of the airscrew propeller, present methods of design, &c., it is in order to bring into clearer relief the parts of the problem which are not yet well in hand—the parts which are as yet outstanding and awaiting our further study. These phases which thus stand out represent in effect the lack of an adequate correlation between the three methods of approach as above described. It is obvious that if we could develop an adequate and reliable correlation between the results of the computation according to method No. 1 and the final test under flying conditions according to No. 3—if, in other words, we could adequately determine the error of No. 1 and hence the correction to be applied in any given case, then a pencil and pad of paper would go a long way towards furnishing the material for the solution of the problem of airscrew design, once that we are permitted, of course, to assume a definite set of operative conditions.

Or, again, if we could know more accurately and more widely the character and amount of error to be anticipated in the use of the small models according to method No. 2, we should be in a position to use the experimented model method with better assurance of definite and reliable results for the full-sized screw later to be constructed. It seems likely that this final correlation of computation with ultimate result may best be made in two stages. The first should comprise a careful study of the relation between the results derived by the computation of method No. 1 and the model test of method No. 2. Such a correlation would then permit us to pass readily from the results by computation to the probable results by model.

The second correlation should then comprise a series of comparative tests to determine with sufficient generality of application, the character and amount of correction to be applied to the results of model test in order satisfactorily to reproduce the results to be expected from full-sized forms.

This would, by no means, require the testing of a full-sized form corresponding to each model. If so, there would, of course, be no use in making model tests. The whole programme might as well be carried out directly by tests on full-sized forms. It appears reasonable to expect, however, that a well selected and not too numerous series of tests, properly distributed among the various characteristics of form and of operation, would serve adequately to give the correlation desired.

With such correlations established, we should then have two methods, Nos. 1 and 2, available for the design of airscrews. No. 1 available with no more than a pencil and pad of paper (once the standard section coefficients determined), and No. 2, by model, ready to supply a vast amount of detailed information regarding operation under varying conditions, and which may be realised rapidly and effectively once the model is made.

If we have spent so much time over these matters relating to the airscrew, it is because of its importance as an element in aerial navigation, and in order that we may the better note just what part of the general problem is still outstanding. This, as we have seen, lies primarily in the matter of the correlation between the three methods outlined. There is indeed need for continuing experimental research, especially on systematically selected forms, both model and full size; and such continuing experimental work combined with carefully directed studies of correlation will go far toward giving us an assured and adequate basis for the practical solution of the airscrew problem as applied to aerial navigation.

Reaction between Airscrew and Plane.—Perhaps the widest and most important outstanding problem in connection with aeroplane propulsion has relation to the reaction between the plane and the propeller—the influence of the structures adjacent to the propeller on its performance, economic and otherwise, and the influence of the propeller on the plane, both as regards its lift and its net resistance to propulsion. This is a field which is largely outstanding. It must be attacked chiefly by the experimental method—by model with results checked up by comparison with full-scale trials so far as practicable. Time forbids more than the mention of this promising and largely uncultivated field of aerodynamic investigation.

Multiple Airscrews on One Shaft.—Of a closely related nature is the problem of the interaction of two or more airscrews on one shaft. This is a problem which is becoming of importance in connection with the increase in power of aeroplane power plants and with the fitting of more than one airscrew on the same shaft. This likewise is a problem which must be approached experimentally—again through model research checked up by comparison with full-scale tests. A beginning has been made on this most important and interesting problem and we may expect, in a not distant future, to find it brought within limits of control similar to those surrounding the problem of the individual airscrew.

Airscrew with Adjustable Pitch.—In addition to these problems which relate to aeroplane propulsion in its general aspects, and more especially when for the sake of simplicity we assume that the aeroplane remains under a uniform *regimen* as regards external conditions, there arises a problem of very great present importance, that of some form of adjustment in the technical characteristics of the plane as a whole permitting it to be made responsive to variations in the *regimen* of operation, as for example, change in the density of the air due to change in altitude, or change of *regimen* required for climbing flight as compared with horizontal flight.

In connection with the prime mover, mention was made of the very important problem of maintaining power at altitude in spite of the decrease in the density of the air. In reality this problem is very intimately bound up with another of scarcely less importance, that of devising means for effectively using such power for propulsive purposes. Without attempting any technical discussion of the question, it will be apparent that the whole question of the operation of the airscrew as a means for absorbing the power of the prime mover and converting it into the propulsion of the plane will depend on the density of the medium in which and on which it operates. Again, in climbing flight a part of the weight of the aeroplane is carried by the pull or thrust of the airscrew. In horizontal flight it is all borne by the planes (assuming the airscrew shaft then horizontal). Hence, the pull or thrust of an airscrew and, indeed, its whole *regimen* of operation may vary widely according as the plane is climbing or flying horizontally. It thus seems reasonable to conclude that for the best results there should be provided some mode of adjustment or compensation so that the airscrew, as it finds itself operating in a medium of continuously decreasing density, or as it finds itself called upon for varying amounts of thrust or pull with varying angles of climbing flight, may be correspondingly adjusted in order to give continuously the best results.

The problem is further complicated by the fact that the aeroplane itself needs a correlative adjustment. As we have already seen, the one factor in aerial flight which remains sensibly constant under all conditions and at all altitudes of flight is the weight of the plane and its equipment. The vertical supporting force gained from the reaction of the air must therefore be maintained constantly equal to this weight at least for the conditions of horizontal flight, while for climbing flight the weight will be divided and borne partly by the supporting planes and partly by the airscrew. The problem of the economic use of power at varying altitudes and under varying angles of climbing flight involves therefore the following chief elements :—

The weight of the plane.
The surface of the wings and their aerodynamic characteristics.
The angle of attack of the wings.
The speed.
The power developed by the engine.
The revolutions of the airscrew.
The area and form of the blades of the airscrew.
The pitch of the airscrew.

These various factors react and interact in a most complex manner and any attempt to discuss the problem in detail would carry us too far afield on the present occasion. We may note, however, that the angle of attack is the one feature about the plane which may readily be varied, while there is no feature of the propulsive agent, the ordinary airscrew, which admits of equally simple correlative variation. What is needed with regard to the airscrew is, indeed, some means of realising an adjustment correlative to the change in the angle of attack for the plane. To this end a change of pitch is most suitable, some means of varying, at the will of the pilot, the pitch of the screw in order that with the fixed diameter and area of surface, and with the work available per revolution of the engine as affected by the density of the air, the pitch may be so adjusted as to secure the number of revolutions best adapted to the economic use of the power given out by the prime mover. This will then ensure the thrust needed to overcome the resistance of the plane at the angle of attack and speed which, taken conjointly, will give the lifting force needed to support the weight of the plane, either in whole or in part, according as the plane is flying horizontally or climbing.

All of this somewhat complicated statement means simply that what is wanted is an airscrew with blades adjustable for pitch. Such an airscrew may be realised by so pivoting the blades that they may be turned about a radial axis, thus changing their angle relative to the axis of the screw itself. Extreme changes of such a character result in a very wide variation of pitch from root to tip and in the end will result in a serious loss in efficiency. There are, therefore, two problems involved :

1. The aerodynamic problem of determining the best form and proportions of an airscrew, the blades of which are intended to be pivotable in this manner, so that under the widely changing conditions of flight which may be met with, there may be effective operation and a well-sustained efficiency.

2. The mechanical problem of so designing and building an airscrew with adjustable blades that it will meet the rigorous requirements imposed upon it by the exacting conditions of aeroplane navigation.

It is perhaps not too much to say that the first problem is already well in hand. We know reasonably well what forms and proportions to give to such an airscrew, and if it were only a matter of design or of the determination of form and proportion, the problem could hardly be called outstanding.

As much cannot be said regarding the second problem. The practical construction of an airscrew with adjustable blades is not an easy matter. Several modes of construction have been attempted, but with only moderate success. The problem is clearly defined, of the highest order of importance, and is outstanding as one of the appliances for which the art of aerial navigation is definitely in waiting.

Stability and Control.—The three fundamental requisites of an aeroplane are strength, movement and stability with control. We have noted some of the problems arising under the requirements of strength, and movement or propulsion. We may now turn very briefly to a glance at the situation regarding stability and control. Any detailed discussion of these problems would be quite out of the question on the present occasion, and time in any event will only allow us a brief glance at the general situation.

Regarding stability and control it is not too much to say that the general principles underlying these characteristics of an aeroplane are now reasonably well understood, due largely to the splendid theoretical and experimental investigations initiated by British scientists and to which certain workers in the same field in the United States may have contributed something, and by no means overlooking certain important contributions by French and Italian investigators. These investigations, both analytical and experimental, have placed the study of these subjects on a reasonably sure foundation, and have served to mark out the way to secure any desired degree of stability which may be desired or which may be consistent with other valuable qualities. We are here confronted with one of those situations, so frequently encountered in scientific and technical work, where a choice must be accepted on some middle ground between wide extremes, and where the attempt to secure some desirable quality in high degree may lead to a limitation of desirable qualities in other directions.

So it is with stability and control. If stability is carried to an extreme, then mobility and quickness of manœuvring are reduced and control in the sense of ready response is lacking. For military purposes, especially for machines of the fighting type where mobility is of the highest importance, this would be a serious shortcoming, and hence such machines cannot be given too much stability in the ordinary sense of the term. On the other hand, for heavy machines of the bombing type, where mobility of evolution is not so vitally important, the margin of stability may be greater. Going to a still further extreme, it is perfectly easy to build a safe moderate speed family carriage sort of machine which will be stable and secure, under almost any conditions likely to develop. Such machines would be scorned by fighting pilots, but when civil aeronautics begins to come into its own after the war and under peace conditions, and there comes a demand for safe machines for civil purposes, including family outings for the week-end from the city to the country or to the sea coast, then we may anticipate a larger recognition of the qualities making for safety and stability, and we shall find machines provided having such characteristics and in practically any desired degree. Here, again, however, there will be degrees of choice, because it will be found that with too high a degree of stability, what may be termed the riding qualities of the plane will be poor, while with low stability the riding qualities may be much smoother.

The general problem is therefore pretty well solved so far as the ground work is concerned. This does not mean, however, that there is nothing further for us to learn in this connection. There are many problems of a detailed nature inviting the student of this fascinating field of study and the solution of which will serve to round out and broaden our general grasp of the problem. In particular, we need further study on the interaction between elements which ensure stability and those which permit mobility and readiness of response to control agencies, to the end that we may control more effectively the combinations which may be desired regarding stability and mobility of evolution.

Again, while the elements of control are well understood, there is room for further study as to the best means of actually developing the control forces required and of applying them to the plane itself. These are partly aerodynamic and partly structural problems each phase reacting more or less on the other.

One instance of problems of this character will serve

to illustrate the type. Thus, we know that an aeroplane is provided with rudder surfaces of two kinds, one to determine movement in a vertical motion, up or down, and the other to determine horizontal motion, right or left. But these motions, vertical and horizontal, assume that the plane itself is horizontal or sensibly so. However, when a plane is circling on a steep spiral or making a quick turn, it is inclined or "banked" in order to avoid side slipping, until, in extreme cases, the wings are nearly vertical, and frequently much more nearly vertical than horizontal. In such cases, the functions of these control services are reversed. Those which, with normal aspects, serve to produce movement right and left will now serve to determine motion rather in a vertical direction, and those which formerly served for movement up and down will now serve to determine motion to the right or left. For intermediate angles of bank, each set of control surfaces will give control forces in both directions, up or down and right or left.

Now, it is by no means sure, having in view this double and interchanging function between these two sets of surfaces, whether we have as yet realised the ultimate and best arrangement either as regards the surfaces themselves or their control by the pilot. It seems decidedly probable that we have not, and that some arrangement yet remains to be devised which will be more effective in the matter of this double and interchanging function of control, and simpler in its relation to the pilot. This and the other like problems are still awaiting investigation and offer a delightfully promising field for the further study of the aerodynamic engineer.

Armament and Instruments.—There still remain two large and important fields, rich in aeronautic problems. There are armament and instruments. I shall attempt no more than the briefest general reference to these two classes of problems.

Those arising under the head of armament are, of course, strictly military in character and but little of interest could, in any event, be said in a public address. Such problems relate naturally to the number, type, and size of guns to be carried, their mounting and special sights; bombs and devices for carrying, aiming, dropping, &c.; questions of armour and protection of vital parts against gunfire or shrapnel burst, &c. Expressed in their most general terms these problems resolve themselves into an attempt all along the line to meet the requirements imposed by the desired military uses of the plane, and to anticipate or improve upon the devices and designs of the enemy in the same fields.

Regarding instruments, little more specific can be said. This field does, however, bristle with problems of the highest interest to the scientist, and may well challenge his best efforts. It is interesting to note the extent to which the modern aeroplane has become a flying meteorological and physical laboratory. Thus, a recent list of aeroplane instruments shows some 25 or 30 different instruments and devices, not indeed all to be carried on one plane, but all included in the general aeronautic military programme, and each serving some specific and important purpose. With these instruments, as with armament, the problems reduce themselves to an effort to meet the military or the navigational and operative requirements of the situation, and in these days of war in particular, to anticipate or improve upon the similar devices and designs of the enemy.

Much of the work relating to these problems under armament and instruments is already done and well done. There do remain, however, many problems, especially of detail or of improvement, and which must be considered as outstanding; but of these I shall attempt no mention or discussion.

By way of conclusion, reference may, for a moment, be made to a problem of the most vital and far-reaching economic importance, and which will be upon us with the arrival of peace conditions. This is the problem of the best economic utilisation of the enormous investment which has been made in aeronautic production, expressed in terms of money and human time and energy, and now represented by factories, machinery and equipment, finished product, trained industrial organisations, human skill and productive capacity.

The discussion of such a problem might well occupy our careful attention for the entire hour, but I can no more than mention it here by name. We can, however, scarcely over-exaggerate its importance, and the appointment of important commissions in England and in the United States for the study of the problems arising under this general head is an evidence that their serious import is appreciated, and we may hopefully await suitable measures of adjustment against the day when we may again turn our thoughts to the occupations of peace.

And so with all our problems; we can only look hopefully forward for the future to give to us such measure of answer as our patience and study may merit. Of one thing, however, we may be sure, and that is that the day will never come when we have no more problems to solve. But, on the contrary, the number of problems still outstanding, as the years go by, is likely, rather, to increase with our acquaintance with the subject, and we may be sure that before this or any like audience under the auspices of the Aeronautical Society of Great Britain, there will never lack material for a discussion of "Outstanding Problems in Aeronautics."

JAPANESE STATE STEEL WORKS.—The estimated output of the State steel works at Yawata, says *The London and China Telegraph*, is put at 400,000 tons, of which 380,000 tons are guaranteed. According to a decision lately reached with regard to the allotment of this output, 14,000 tons will be assigned to the navy, 62,000 tons to the army, 70,000 tons to the Imperial Railway Bureau, 55,000 tons to other Government services, and 174,000 tons will be allotted for general purchase.

MATERIALS USED IN THE IRON AND STEEL TRADES.

THE evidence on which the Iron and Steel Trades Committee based their report on our After-War Policy deals with ores, smelting, rolling, casting, wire-drawing, forging, &c. Omitting fuel, and stopping short of machine making, they deal with iron and steel "materials" for engineering work in the proper sense of the term. The view taken is that this group of processes, dealing with raw or semi-finished material, is of national importance. That, for instance, prosperity in exporting coal, or machinery, is delusive, if at the same time we fail to be self-dependent as regards materials. The evidence may be summarised briefly in its main results, readers being referred to the report, White Paper 1918 [Cd. 9071], for details. Of course, non-iron metals are outside the scope of this report.

Iron Ore used in Britain.—We produce two-thirds and import one-third, the value of the latter being about 19s. per ton delivered.

Iron Ores.	1910. Tons.	1913. Tons.
Native	15,226,000	15,997,000
Imported ...	7,019,000	7,442,000
Total ...	22,245,000	23,439,000

Of the above 200,000 tons is manganiferous, value 16s. 4d. per ton. There is, in addition, the manganese ore, all imported, 601,177 tons in 1913, value 43s. per ton. Only a trifling amount of iron ore comes from enemy territory, and over half the manganese import is from British Possessions. We have no native manganese ore. German production of native ore was twice as much, and American four times as much as ours.

Pig-Iron and Steel.—In nine years, 1905–13, our production of pig-iron fell slightly, and our production of steel rose slightly. Our requirements increased largely and were met by imports, not of pig iron, but of steel, much of it highly manufactured.

BRITISH PRODUCTION OF PIG-IRON AND STEEL.

Annual Average of Three-Year Periods.	Pig-Iron. Tons.	Steel. Tons.
1905–7	9,969,000	6,265,000
1908–10	9,866,000	5,945,000
1911–13	9,512,000	7,044,000

Our pig-iron production fell 4 per cent., and in the same period German production increased 70 per cent. and American 35 per cent. The totals were: Germany nearly twice ours and America three times ours. In steel the proportions are 1 : 2½ : 4. We sold more coal to Germany, who used it to develop her pig-iron, steel casting and steel rolling industries, and sold us steel in exchange; at the same time developing her soldier-producing industry.

There are no official statistics of total production of engineering materials. The Committee, however, obtained production figures from various associations of manufacturers, and these are of great value, though incomplete. All production figures are annual.

Steel Castings.—One association states that, mainly in heavy castings, their total returns are:—

	£
Capital employed	2,688,000
Products (value)	2,500,000
	Tons.
Products	97,448

The average value per ton is over 25*l.* 10s.

Steel Forgings.—Three associations of forgemasters, making heavy forgings for land and marine work, state that their returns are:—

	£
Capital employed	6,411,000
	Tons.
Products	64,270

The value of the products are given in one case only, the English and Scottish Association. The complete separate return, included in the above, is of interest:—

	£
Capital employed	450,000
Products (value)	339,000
	Tons.
Products	12,000

The value per ton is 28*l.* 5s.

Various Steel Products.—Other production returns may be put in one table:—

Products.	Weight. Tons.	Value. £
Bridge, &c.		
Bridge, &c.	500,000	—
S.D. tubes	36,000	1,000,000
Steel nails	23,223	—
Tubes	—	5,500,000
Tyres and axles ...	—	2,300,000
Wheels and axles ...	—	1,749,000
Wire	200,000	—
Wire netting	35,000	700,000
Wire rods	119,600	—
Galvanised sheets ...	838,000	11,000,000

There are also the great branches of bar, hoop, strip, plate, girder, rail, &c., production, of which some returns are given.

Cast Iron Products.—Iron castings form a highly valuable part of our materials, despite the relative advance in the use of steel. Three Associations give production returns: (*a*) light castings; (*b*) heavy castings; and (*c*) pipe castings:—

	Capital. £	Annual Production. Value. £	Weight. Tons.
(*a*) ...	—	5,000,000	—
(*b*) ...	2,000,000	3,250,000	325,000
(*c*) ...	2,150,000	4,000,000	510,000

25 per cent. of the light castings and 43·5 per cent. of the pipes are exported.

Exports and Imports.—These form the only index to the general position. The figures practically correspond to materials and do not include machinery.

IRON AND STEEL: MANUFACTURES THEREOF.

Imports.	1910.	1913.
Britain ...	9,291,000	15,619,000
Germany	3,924,000	4,615,000
U.S.A.	5,382,000	4,702,000
Exports.		
Britain	43,441,000	54,692,000
Germany	33,871,000	55,683,000
U.S.A.	16,585,000	30,275,000

Even in this brief period the tendency is strongly marked against us. At the end of it we bought much more and our rivals no more. Our foreign sales increased substantially, but those of our rivals increased enormously. Germany passed from second to first place.

Freights.—A great deal of precise information is given in the report. The effect of it is that what amount to substantial preferences on production operate against British material producers. These originate chiefly from German State action, and spread to shipping lines and railways on both sides.

Competition.—The nature of the competition is not that of independent rival producers, but of a German State directed campaign against British production. Special branches are selected for concentrated attack and followed by similar attacks on other branches. German production is increased beyond German demands in lines where cheapness follows on large scale plants, and the surplus product is forced on the out-German markets, chiefly on ours because it is duty-free. "Dumping" becomes, not the disposal of a chance surplus, but the calculated production of a surplus that can be sold cheap. The Germans take their profit on the total result, and subsidise special branches to bring in an over-all gain. They look to the transfer of employment to Germany as a national gain worth achieving at a temporary sectional loss, the section losing being compensated at once by the profits of other sections.

American competition is different in motive. It arises from large private capital combinations, and is not influenced by national bias. It is not directed by the United States Government to serve political ends. Nevertheless, in certain lines it is serious competition.

The majority of the Committee take a bold and candid line of policy. They declare that it is a matter of national interest that the group of British material-producing industries should be in a prosperous condition and able to supply the national requirements and develop the export trade. They make very marked advances to gain labour and trade union co-operation with employers, and substantially all the proposals are endorsed by so strong a trade union leader as Mr. John Hodge, M.P.

The committee, however, was not unanimous in its report. Sir Hugh Bell, Mr. John E. Davison and Mr. James Gavin did not sign Section III, "On Commercial Reconstruction after the War." In regard to Section IV, on "Iron Ore," Sir Hugh Bell objected to State intervention in ore supplies. Under Section V, on "Organisation in the Iron and Steel Industries," Mr. Davison dissented from the recommendation of a change in our fiscal policy, while Sir Hugh Bell was in "essential and almost total disagreement with the arguments and many of the statements." On the subject of "Labour," Section VII, objections on minor points were raised by Sir Hugh Bell, Mr. Davison and Messrs. Gavin and Hodge. Section VIII, on "Protection," is accompanied by a caution signed by Mr. James Garvin and Mr. John Hodge, by a note by Mr. Mure Ritchie, and by a dissenting statement by Sir Hugh Bell and Mr. John E. Davison. Generally speaking, the report is in favour of protection in some form, but one or more members enter protests against many of the propositions.

ANALYSIS OF WHITE METAL.—As rapid analyses of white metal are frequently needed, the following note on the subject, due to Dr. Paul Drawe (*Zeitschrift für Angewandte Chemie*, April 30, 1915), may be of interest, though there is little novelty about the various proposed determinations. About 1 gram of the metal borings is dissolved in 10 cub. cm. of nitric acid of density 1·4, the solution is diluted with 50 or 100 cub. cm. of hot water, boiled for five minutes, and then filtered. The moist precipitate (consisting of oxides of tin and antimony) is washed into an Erlenmeyer flask, heated and diluted with water; about 2 grams of pure powdered iron are then dropped into the flask, and the liquid is kept at 80 deg. C. for about an hour, air being excluded; the tin will then have been dissolved as stannous chloride (which is titrated with iron chloride, no indicator being needed), while the antimony is precipitated as metal on the excess of iron, which is extracted with hydrochloric acid. The original filtrate contains the lead, copper, iron and zinc of the white metal. Sulphuric acid is added to the solution, which is evaporated to dryness and redissolved in water; the lead remains insoluble as sulphate, the other metals pass into solution. Copper is first precipitated by sulphuretted hydrogen; the iron is then oxidised with bromine water and precipitated as hydroxide by caustic soda, and the zinc is finally precipitated from the filtrate, previously acidified with hydrochloric acid, by soda.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACT OF 1907.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not illustrated.

Where inventions are communicated from abroad, the Names, &c., of the Communicators are given in italics.

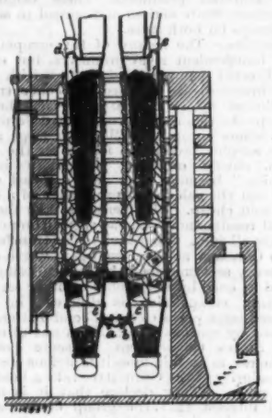
Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 6d.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Act.

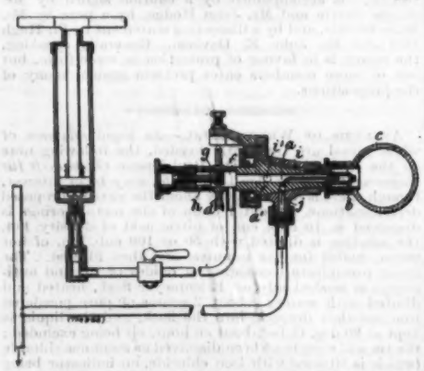
GAS ENGINES, PRODUCERS, HOLDERS, &c.

114,937. F. M. Perkin, London, and J. West, Southport Destructive Distillation. (1 *Fig.*) June 11, 1917.—This invention relates to the destructive distillation at high temperatures of carbonaceous materials. The invention consists in expediting the heating up of the coal-charge, so as to reduce the period of low temperature distillation to a minimum, by causing an inert gas to travel upwards through the red-hot coke in the lower portion of the retort where the gas becomes highly heated, then through the partially-coked mass of coal, from which it carries off volatile matter, and finally through the coal,



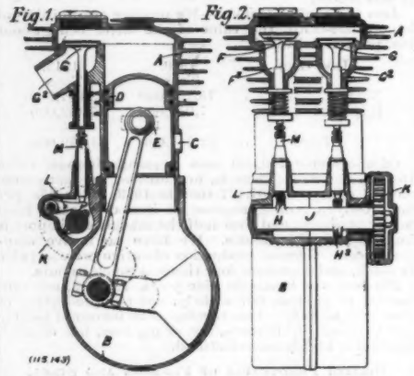
which is receiving its first heat in the hot zone of the retort, where the inert gas gives up heat, but, owing to its rate of travel, is not sufficiently cooled to cause condensation or excessive condensation of the volatile matter on the coal, the whole of the gas and distillates being then withdrawn from the retort by the gas off-take. The supply of inert gas, such as, for example, stripped coal gas or producer gas, is introduced by the pipes *a*, *b* into the coke chambers *c* at the lower end of the retorts. The whole of the gas from the carbonising coal is withdrawn from the coal by the gas off-takes *d*, *e* immediately after leaving the hot zone of the retort. (*Accepted May* 1, 1918.)

114,866. E. Dobson, Wimbledon. Internal-Combustion Engines. (2 *Figs.*) March 16, 1917.—This invention relates to apparatus for starting internal-combustion engines of the type in which liquid fuel and air are simultaneously introduced into the induction pipe through a spraying nozzle to which the fuel and air are conveyed through separate pipes leading to the nozzle from a source of liquid fuel supply and from the atmosphere, the duct leading from the atmosphere being formed in a rotary plug cock on the end of which the spraying nozzle is fitted, but controlled by a separate valve, while the liquid fuel duct is in part formed in the rotary plug cock by turning which the supply



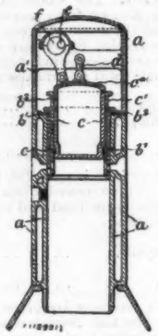
of liquid fuel can be regulated or shut off at will. The cock *a*, on which the spraying nozzle *b* is provided and which is connected to the induction pipe *c*, is operated by a grooved pulley *d* fixed on an extension of the plug *a*1. Air is supplied under pressure to the air duct *f* leading through the plug *a*1 to the spraying nozzle *b*. The duct *f* is fitted with a valve *g* arranged to close an opening *h* to the atmosphere upon the application of pressure, the valve *g* being arranged to open when the suction of the engine becomes operative. By the employment of air under pressure, as described, petrol vapour for starting is supplied to the engine cylinder on the firing stroke of the piston, and fired to give the initial explosion, after which the suction method of working comes into operation until the engine is completely started, and when running under suction, additional air can be added through the auxiliary duct hereinafter described. This auxiliary duct is conveniently formed by a groove *i* in the plug *a*1, capable of being put in communication at one end with an air inlet aperture *i*1 in the cock *a*, while the other end terminates near the spraying nozzle *b*. This auxiliary air duct is so arranged that it is brought into operation by turning the plug in the direction opposite to that for shutting off the liquid fuel, the liquid fuel duct *j* being maintained open in this position by a short circumferential groove in the plug. (*Accepted May* 1, 1918.)

115,143. G. E. Stanley, Coventry. Internal Combustion Engines. (2 *Figs.*) July 4, 1917.—This invention relates to two-stroke-cycle internal-combustion engines. According to this invention, two or more exhaust valves are provided, and are adapted to be operated in turn during successive exhaust strokes. A is the cylinder, and B the crank chamber, whilst C is the inlet port which is uncovered when the piston D approaches the top of its stroke. On the down stroke of the piston, the gas is compressed in the chamber B, ready to be afterwards transferred to



the cylinder by a transfer passage, the upper end of which is indicated at E in Fig. 1. There are two exhaust valves F, G, located in a pocket at the side of the cylinder head, and provided with separate exhaust passages F2, G2. The valves are lifted alternately by cams H, H2, on a cam shaft J driven at half-engine speed by spur gearing K; rockers L and tappet rods M being interposed between the cams and the valve stems. Obviously, if desired, the cam shaft may run at quarter-engine speed, two swells then being provided on each cam. (*Accepted May* 8, 1918.)

112,921. H. V. J. Jouffret, Paris, France. Sleeve Valve Internal Combustion Engines. (1 *Fig.*) January 26, 1917.—This invention refers more particularly to internal-combustion engines in which the admission and exhaust are controlled by means of a sleeve or sleeves. *a* is the cylinder provided with a head *a*1; *b*1 and *b*2 are the two sleeves mounted concentrically, and having their movements controlled in the ordinary manner. *c* is a piston-like fitting, the outer diameter of which is equal to the



inner diameter of the sleeve *b*2. The fitting *c* is connected by a link *d* to the head *a*1. It will be seen that the fitting *c* automatically comes into the correct position for constituting the inner guide of the sleeve *b*2. The fitting *c* may be provided with a closed top *c*0 as shown, thus avoiding the accumulation of lubricating oil within the cavity. The shaft *e* and the excentric *f* for controlling the sleeves, are preferably located in the head. (*Accepted May* 8, 1918.)

GUNS AND EXPLOSIVES.

115,013. W. Youlten, London. Machine Gun Mounting. (5 *Figs.*) January 13, 1917.—The invention consists in a light and easily-portable device or apparatus, which can be collapsed so that it can be stowed into a small compass and easily transported from place to place, but which is adapted to be placed so that it rests practically flat upon a firing step, upon sand-bags or the ground. The apparatus constructed, according to the invention, for supporting a heavy machine gun, comprises in combination, a tubular framework shaped substantially to the form of two oppositely-directed isosceles triangles having a common base; two tubes or arms hinged at the two angles at the ends of the base, a fitting carrying the machine gun connected to the outer ends of the said arms, a central tube extending in the longitudinal axis of the said framework, another tube or its equivalent pivotally connected at one end to a collar sliding on the said central tube and at the other end to the fitting carrying the gun, and means for holding the whole apparatus in the raised position. *p* are tubes forming a framework, and provided with spikes for enabling the framework to be firmly supported upon the ground. *r* is a cross tube connecting two opposite angles of the said framework. *s*, *s* are other tubes pivoted at their lower ends and connected together at their upper ends. These tubes carry at the top a block *z*. 3 is a sleeve or tube carrying at the lower portion two lugs adapted to come on each side of the block *z*, and they constitute therewith a pivotal connection. The tube 3 has pivotally-mounted therein a pin 7, which carries the lower portion of a circular clamp 8 for holding the gun. 13 is a tube extending from the cross tube *r* along the middle of the lower frame. 14 is a collar adapted to slide on the tube 13, and having hinged thereto one end of a tube 16, the other end of which is pivoted to the upper portion of the tubes *w*. 19 are strong laminated springs bolted to the tube 16. The machine gun is bolted in position in the

Fig. 1.

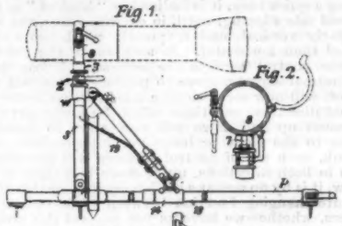


Fig. 2.

Fig. 3.

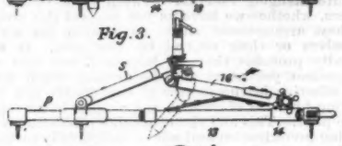


Fig. 4.

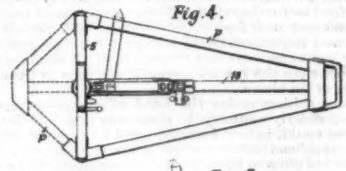
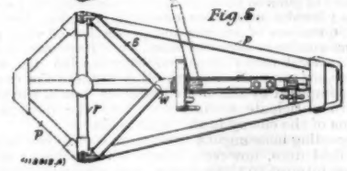


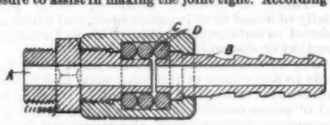
Fig. 5.



clamp 8. By releasing a screw fitting and pushing the gun upwards, the frame rises into the position shown at Fig. 1, in which the gun can be traversed from side to side and tilted. When it is required to replace the old cartridge belt by a new one, or desirable for other purposes, the frame may be lowered into the position shown at Fig. 3. The spring 19 coming into contact with the central tube 13, acts as a buffer, and assists the gunner in pushing up the device. (*Accepted May* 1, 1918.)

HYDRAULIC MACHINERY.

115,081. Vickers, Limited, Westminster, London, J. McKechnie, Barrow-in-Furness, and C. Evans, Barrow-in-Furness. Hose or Pipe Couplings. (5 *Figs.*) April 24, 1917.—This invention relates to a hose or pipe coupling for use with liquid under pressure, of the type in which elastic packing is employed, so acted upon by the internal pressure as to enable the pressure to assist in making the joint tight. According to this



invention, a flanged external coupling sleeve C connects a pair of coupling members A, B, formed with reduced adjacent projecting ends, and the elastic packing D is placed in the annular space between the sleeve C and the reduced ends A, B, which packing is pressed against the shoulders of the coupling members, the sleeve flanges and the other internal faces of the coupling. The internal fluid pressure acts merely to press the packing more tightly against the adjoining surfaces. (*Accepted May* 8, 1918.)

115,160. Sir W. G. Armstrong, Whitworth and Co., Limited, and W. Thompson, Newcastle-upon-Tyne. Hose Pipes. (5 *Figs.*) August 2, 1917.—This invention relates to connections for hose pipes. According to this invention, the spigot portion of the connection whose end is to be pressed against a washer in the socket portion, is provided with lugs while the socket is tapped along its circumference, with holes for the passage of screws which bear against the lugs. The screws are provided each with a transverse slot to allow the passage of the lugs in order to allow the insertion of the spigot into the socket, and its withdrawal therefrom by merely giving

Fig. 1.

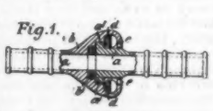


Fig. 3.

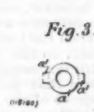


Fig. 5.

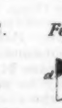


Fig. 2.

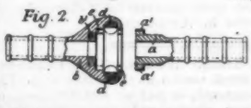


Fig. 4.

a partial turn to the screws; the socket also is cut away at the top to allow the passage of the lugs after they have passed the screws. *a* is the spigot and *a*1 its lugs; *b* is the socket, *b*1 its washer; the socket is provided with tap holes *c* for the passage of the slotted screws *d*, and is also cut away at *e* to allow of the insertion and withdrawal of the spigot *a*. (*Accepted May* 8, 1918.)

THE MONDEVILLE-COLOMBELLES IRON AND STEEL WORKS (TH

(For Descr. Page

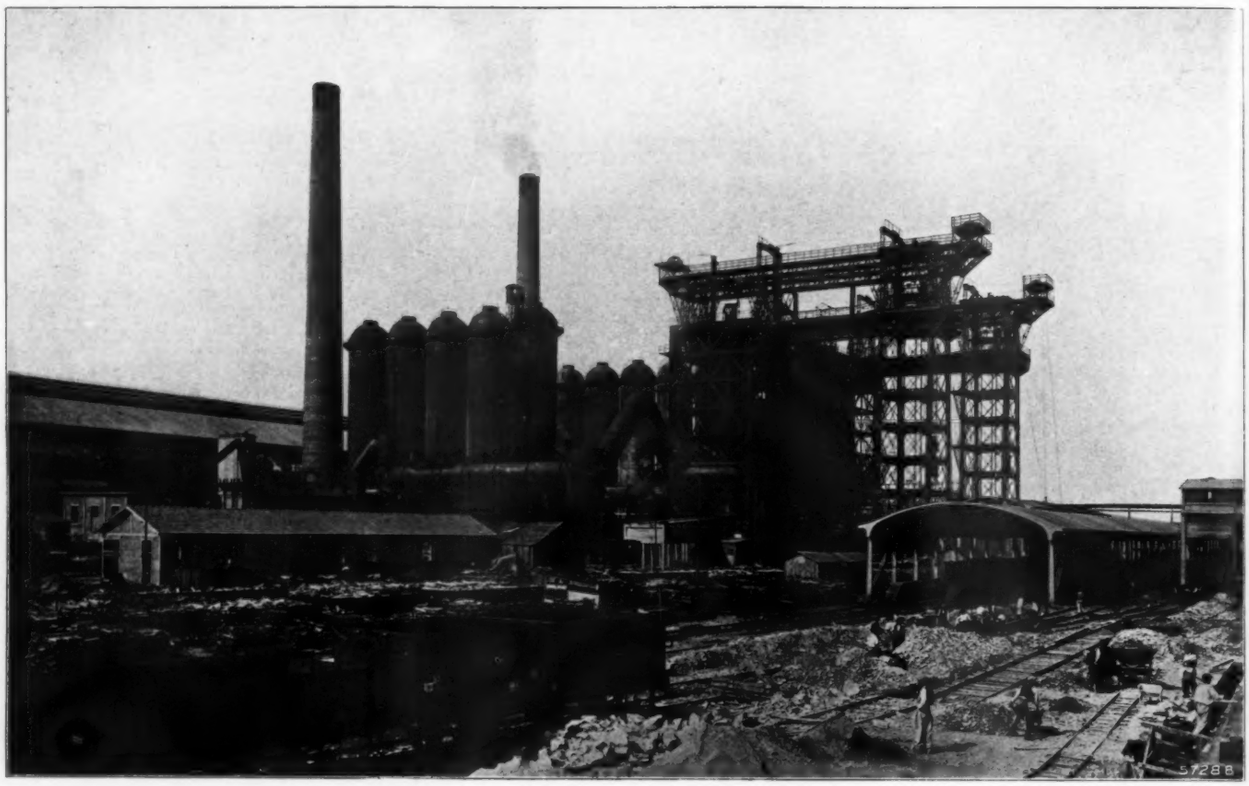


FIG. 2. GENERAL VIEW OF BLAST FURNACE PLANT.

FIG. 4. CHARGING A 25 TO 30-TON OPEN-HEARTH FURNACE.

S OF THE SOCIÉTÉ NORMANDE DE MÉTALLURGIE, CAEN, FRANCE.

(For Description, see Page 136.)

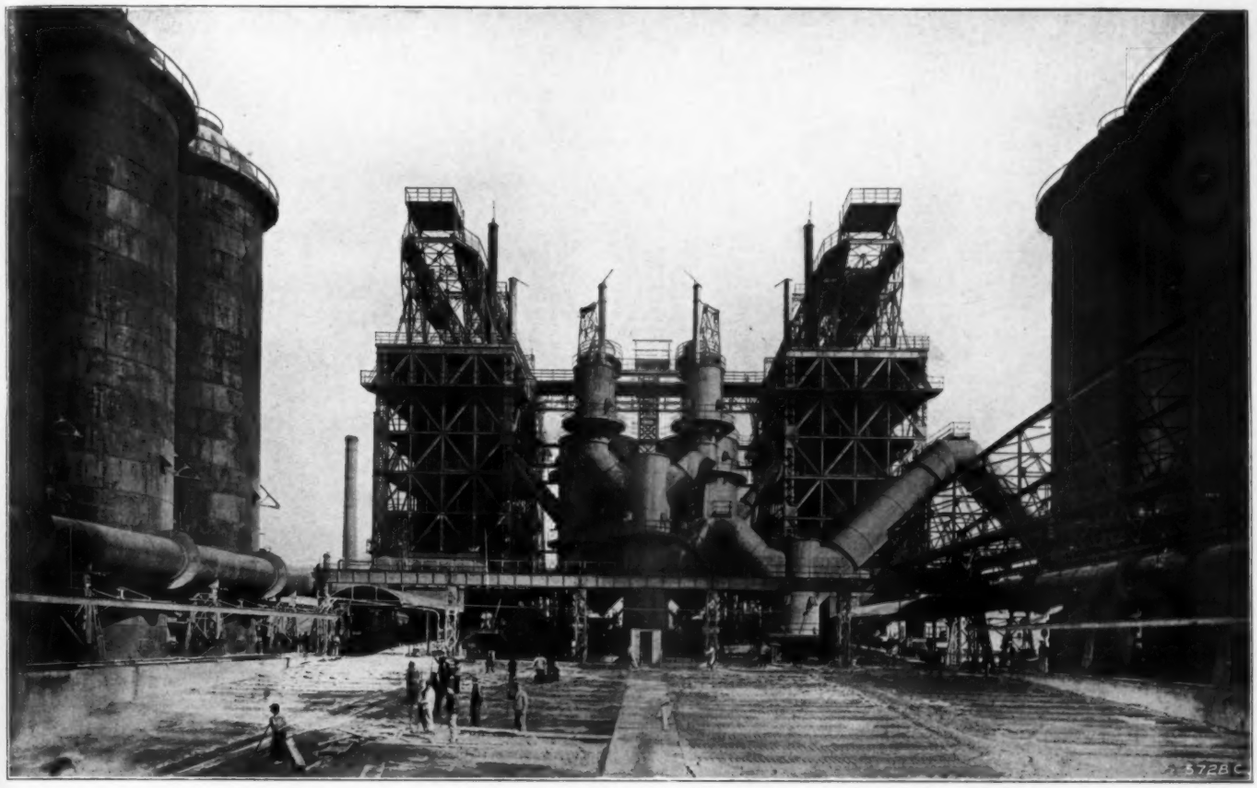


FIG. 3. BLAST FURNACE PLANT, SHOWING PIG BED.

FIG. 5. TAPPING A 25 TO 30-TON OPEN-HEARTH FURNACE.